

NOV 8 1928

W. B. No. 965

UNITED STATES DEPARTMENT OF AGRICULTURE
WEATHER BUREAU

VOLUME 56

NUMBER 8

MONTHLY WEATHER REVIEW

AUGUST, 1928

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UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON
1928

CORRECTIONS

MONTHLY WEATHER REVIEW, June, 1923:

Page 216, in the date line (under author's name "Totonto" should be "Toronto."

Page 219, line 24, " 10^1 watt-seconds" should be " 10^7 watt-seconds."

Same page, second column, in the second line of the equation near the foot of the page, the multiplication sign (\times) should be a plus sign (+).

MONTHLY WEATHER REVIEW

Editor, ALFRED J. HENRY

Vol. 56, No. 8
W. B. No. 965

AUGUST, 1928

Closed October 3, 1928
Issued November 2, 1928

WEATHER AND THE COTTON BOLL WEEVIL

By J. B. KINCER

[Weather Bureau, Washington, D. C., September 12, 1928]

The cotton boll weevil is of Mexican origin and first appeared in the United States in 1892, near Brownsville, Tex., on the Rio Grande River. It spread slowly northward and eastward in the succeeding years, and by 1903 had reached the Louisiana border, while three years thereafter southeastern Oklahoma and extreme southwestern Arkansas were invaded. Thence the spread was irregular from year to year, depending largely on weather conditions. In 1916 southwestern Tennessee and the greater part of Georgia had been invaded, and by 1922 practically the entire Cotton Belt had been overrun.

In a general way, the weather influence on the activities and consequent damage by the weevil was apparent soon after their appearance in this country. As early as 1906 Mr. W. D. Hunter, in charge of cotton boll weevil investigations, of the Bureau of Entomology, recognized the dominating weather influence and the consequent importance of weather as a natural control. The following extracts are taken from a report by him, published in the Yearbook of the Department of Agriculture for that year, pages 313-324:

* * * In general, the drier and freer from timber the less is the damage by the weevil. The reasons for this are that dryness increases the death rate of immature stages in the fallen squares enormously in summer, and the absence of the protection afforded by timber contributes equally to a decrease in the number of adults in the winter. When the foregoing conditions are combined with low winter temperatures, as happens in northwestern Texas, there is a total of conditions most disastrous for the weevil. The reverse of these conditions is found in the timbered valleys of eastern Texas and Louisiana, where the precipitation is much heavier. * * *

For a long time it has been recognized that the most important single factor in assisting in the production of a cotton crop in a weevil-infested region is dryness during the growing season. An excellent illustration of this is furnished by the condition in Victoria County, Tex., during the spring of 1906. The crop of that year in Victoria County is much the largest ever produced, although the acreage probably was not as large as has been planted in other seasons. The exact records regarding production are not available at this time, but a very conservative estimate of the crop is 13,000 bales. From the accompanying table (not reproduced) it will be seen that May and June were abnormally dry months; in fact, the total precipitation for April, May, and June (4.19 inches) was less than half of the mean total for these months for the five preceding years (9.28 inches). There can be no error in estimating the effect of dryness in this case, on account of the number of weevils present. In fact, far more than the usual number of hibernating weevils appeared in the fields of Victoria County up to the end of April. In one instance, a total number of about 1,500 per acre was shown to have come to a certain field. Of course, due allowance must be made for the effect of the work of parasites and the ant *Solenopsis geminata*, referred to elsewhere. However, the dryness rather interfered with the work of the ant and certainly did not facilitate greatly the work of the parasites. Dryness, therefore, must be considered as the controlling factor.

The importance of the weather as a natural control of the boll weevil was observed also by officials of the Weather Bureau engaged in weather and crop reporting work very soon after infestation in this country. Throughout the period of their menacing presence the Bureau in its weekly weather and crop reports has, from year to year, featured this phase of the problem of cotton growing, by indicating in its summaries whether the prevailing weather had been favorable or unfavorable for weevil activity; also the probable effect of low winter temperatures on those in hibernation, based on a general broad knowledge of the weather-weevil relation.

There are three distinct periods of weather influence: (1) The prevailing conditions during the concurrent year, or the growing season for which weevil damage is considered; (2) The weather during the winter immediately preceding, primarily as to low temperatures, and (3) That for the preceding summer as influencing the number of weevils going into hibernation. In the first and third cases moisture is much the more important, and in the second low temperatures as related to mortality of the insects in hibernation. These three distinct periods of weevil influence are discussed by the Secretary of Agriculture in his report for 1927, published in the Yearbook of the Department of Agriculture for that year, page 57. In commenting on the weevil damage in 1927, he states:

Continuation of general drought conditions in the Cotton Belt in 1926 reduced damage by the cotton boll weevil during that year. However, large amounts of poison were used on cotton, primarily for the leafworm, which covered much of the territory west of the Mississippi River, with lighter injury in parts of Mississippi and Alabama. While this poison helped to destroy the weevils in the areas treated, the absence of rain during the latter months of the season was probably more important in effecting a large degree of natural control.

As a result, the insect entered hibernation in greatly reduced numbers in most of the Cotton Belt. Owing, however, to the fairly mild character of the winter of 1926-27, the percentage of weevil emergence in the spring was higher than for some years. The fairly abundant holdover of weevils, coupled with climatic conditions favorable to the insect during the succeeding months, resulted in boll weevil damage to cotton during 1927 considerably more extensive than had been experienced for several years.

Data used.—In the May, 1928, issue of Crops and Markets, a publication of the Bureau of Agricultural Economics of the Department of Agriculture, there was included a table, showing, for each State of the Cotton Belt, the estimated percentage reduction of cotton from a full yield per acre, occasioned by boll-weevil damage, for the period 1909-1927. In 1909, however, only two States had been overrun by the weevil, and even as late as 1918 a small portion of Georgia had not been affected. Therefore, the number of years available for study is

limited, and the period of weevil infestation in a few States too short to afford sufficient data to include them in this survey, but all the more important cotton States, except the Carolinas and Tennessee, have been included. The number of years used for the several States are as follows: Texas, Louisiana, and Mississippi, 15; Alabama, 12; and Georgia, Arkansas, and Oklahoma, 10 each.

Weevil damage for so large an area as the Cotton Belt of this country can not be accurately determined by direct observational methods, but at the same time the data used are the best available as to weevil activity, while the uniformity of agreement between the prevailing weather and estimated damage for the several States, as shown by this study, strengthens the belief that the figures are substantially correct. There is no question as to the accuracy of the weather data, as they are based on direct instrumental observations. Again, the period is rather short for unquestioned faith in the significance of the mathematical results obtained for individual States, but at the same time the total years of observation for the seven States afford 87 separate determinations, with a remarkable uniformity shown in the weather-weevil relationship throughout the series.

The weather data used are given in Table 1. They include (a) relative humidity, concurrent year; (b) number of days with rainfall, concurrent year; (c) number of cloudy days, concurrent year; (d) rainfall, concurrent year; (e) lowest winter temperature, preceding winter; (f) relative humidity, preceding year; (g) percentage of possible sunshine, preceding year; (h) number of days maximum temperature 90° or higher, preceding summer; and (i) rainfall, preceding year. The numerals at the heads of the several columns indicate the period of the seasons used, as stated in a footnote. There is also shown in this table the computed weevil damage from the weather data, in percentage reduction of cotton yield (\bar{X}), and the estimated reduction reported by the Department of Agriculture (X). The last line shows for each State the correlation coefficient between each weather phase and the percentage of weevil reduction in yield (column X).

The number of days with rainfall, the number of cloudy days, and the total rainfall, for both the concurrent and preceding summers, are based on the records of all Weather Bureau stations, first-order and cooperative, for the respective States, a total of more than 600 stations. The relative humidity, the lowest winter temperatures, the percentage of possible sunshine, and the number of days with maximum temperature 90° or higher, represent the averages for all first-order stations within, or on the border of, the respective States. For Texas sunshine data are not available at a number of stations, and, consequently, the approximate complement of this, or the percentage of cloudiness during the daylight hours, was substituted for sunshine data, which gives a positive correlation with weevil damage for this phase in that State, as against a negative one for the other States where sunshine data were used.

The relative humidity represents the mean for the 7 p. m. observations up to and including 1917, during which time only two relative humidity observations were made daily, at 7 a. m. and 7 p. m., local time. Beginning with 1918, relative humidity observations were made at noon, in addition to the above, and from that year to 1927, inclusive, the mean of the noon and p. m. data was used. The early morning observations were not included, as it was found that records were relatively more important during the warm period of the day when readings are normally lower. The number of days with rainfall

include all days on which 0.01 inch or more of rain occurred.

Only the more important weather data were used for each State, determined by straight correlations between the individual phases and weevil damage, and the correlation of the several weather phases among themselves. (See Statistical Correlations of Weather Influence on Crop Yields, by J. B. Kincer and W. A. Mattice, MONTHLY WEATHER REVIEW, February, 1928.) In all cases the best results were obtained by including one or more weather phases for each of the three periods, the concurrent summer, the preceding winter, and the preceding summer, as shown in Table 1. Moisture stands out as the most important summer factor, and the lowest temperature reached during the winter as the most important for that period.

The summer relative humidity is especially significant. The weevils deposit their eggs in the squares and young bolls, and the larvae, when hatched, feed on the interior substance of the squares and bolls. When punctured, squares, usually, and many young bolls drop to the ground in a few days, and, if it is hot with the atmosphere dry, favoring rapid evaporation of moisture from the fallen squares or young bolls, the larva may die from intense heat, or its food supply, consisting of the interior substance of the squares or bolls, be dried up; thus the per cent of emergence is reduced. On the other hand, moist, cloudy, rainy weather favors a rapid increase in numbers, from generation to generation, of which there are several, through the growing season.

Texas.—The first-order station data are the means for the stations at Abilene, Amarillo, Fort Worth, San Antonio, Taylor, and Shreveport, La. The weather data used (see Table 1) were (a) relative humidity, June and July, concurrent year; (e) lowest winter temperature, preceding winter; (f) relative humidity, July and August, preceding summer; and (g) percentage of cloudiness (substituted for sunshine in this case, as previously stated), June to September, preceding year. The multiple correlation coefficient for these and weevil damage (column X) is 0.934, as shown in equation 6, while equations 7 and 8 give the constants from which weevil damage for the several years was computed. The straight correlation between the computed damage and that reported by the department is 0.94, while the relation is graphically shown in Figure 1.

THE MULTIPLE CORRELATION FOR TEXAS

$$R^2 = \beta xa \cdot rax + \beta xe \cdot rex + \beta xf \cdot rfx + \beta xg \cdot rgx \quad (1)$$

Equation for computing the betas:

$$\left. \begin{aligned} \beta Xa + rae \beta xe + raf \beta xf + rag \beta xg &= +0.62 \\ rea \beta Xa + \beta xe + ref \beta xf + reg \beta xg &= +0.71 \\ rfa \beta Xa + rfe \beta xe + \beta xf + rfg \beta xg &= +0.69 \\ rga \beta Xa + rge \beta xe + rgf \beta xf + \beta xg &= +0.68 \end{aligned} \right\} \quad (2)$$

Solving (2) gives

$$\left. \begin{aligned} \beta Xa &= +0.424; \beta xe = +0.252; \\ \beta xf &= +0.509; \beta xg = +0.118 \end{aligned} \right\} \quad (3)$$

Substituting in equation 1 gives

$$R^2 = 0.424 \times 0.62 + 0.252 \times 0.71 + 0.509 \times 0.69 + 0.118 \times 0.68 \quad (4)$$

$$R^2 = 0.87325 \quad (5)$$

$$R = 0.934 \quad (6)$$

The regression equation:

$$\begin{aligned} \bar{X} = M_x + \beta_{xa} \frac{\sigma_x}{\sigma_a} (A - M_A) + \beta_{xe} \frac{\sigma_x}{\sigma_e} (E - M_E) \\ + \beta_{xf} \frac{\sigma_x}{\sigma_f} (F - M_F) + \beta_{xg} \frac{\sigma_x}{\sigma_g} (G - M_G) \end{aligned} \quad (7)$$

Where \bar{X} is the computed weevil damage; X weevil damage reported by the Department of Agriculture; A , E , F , and G , the respective weather data, and M_A , M_E , M_F , and M_G , their means.

Solving (7) gives

$$\bar{X} = 0.690 A + 0.489 E + 0.836 F + 0.201 G - 77.35 \quad (8)$$

Oklahoma.—The weevil entered southeastern Oklahoma about 1905, but made very little progress for several years, with damage as late as 1910 to 1917, inclusive, averaging less than 2 per cent per year. The period covered by this study begins in 1918 and includes the 10 years from that date to 1927. The weather data used in the computations are (d) Table 1, number of days with rainfall, July and August, concurrent year; (e) lowest temperature, preceding winter; and (f) relative humidity, July and August, preceding year, with first-order station records for Fort Smith, Ark., and Oklahoma City. The multiple correlation coefficient between these and damage by boll weevil (column X) is 0.93. The constants from the regression (computed as for Texas) are $2.001 D + 0.653 E + 1.489 F - 93.87$. The straight correlation coefficient between computed damage (column \bar{X}) and damage reported by the department (column X) is also 0.93, while the relation of these is shown graphically in Figure 1.

Arkansas.—This State was invaded about the same time as Oklahoma, and the period used is the same. The weather data include (b) number of rainy days, June and July, concurrent year; (e) lowest winter temperature; (f) relative humidity, July to September, preceding year, and (i) rainfall, July and August, preceding year, with first-order station records for Fort Smith, Little Rock, and Memphis, Tenn. The multiple correlation coefficient between these and weevil damage is 0.93. The constants are $1.889 B + 0.357 E + 0.820 F + 2.013 I - 87.59$. The straight correlation coefficient between the computed damage and reported damage is also 0.93.

Louisiana.—Period used 15 years, 1913–1927, first-order station data Shreveport, La., and Vicksburg, Miss. Weather data used (d) rainfall, June and July, concurrent year; (e) lowest winter temperature; (g) percentage of sunshine, June and July, preceding year; (i) rainfall, July and August, preceding year. The multiple correlation between these and weevil damage is 0.90. The constants are $1.439 D + 0.289 E - 0.284 G + 0.822 I + 9.39$. The straight correlation between computed damage and reported damage is 0.89.

Mississippi.—The period covers 15 years, 1913–1927, with first-order station records Memphis, Tenn., Meridian and Vicksburg, Miss. Weather data used (a) relative humidity, July and August, concurrent year; (c) number of cloudy days, April to August, concurrent year; (d) rainfall, June to September, concurrent year; (e) lowest winter temperature; (f) relative humidity, July and August, preceding year, with a multiple correlation of 0.96. The constants are $0.588 A + 0.352 C + 0.690 D + 0.701 E + 0.563 F - 87.90$. The straight correlation between computed damage and reported damage is 0.96.

Alabama.—The weevil had practically overrun Alabama in 1916, and the period used for that State was the 12 years 1916–1927, with first-order station records for Birmingham, Montgomery, and Meridian, Miss. The data used were (a) relative humidity, July and August, concurrent year; (d) rainfall, July and August, concurrent year; (e) lowest winter temperature; and (h)

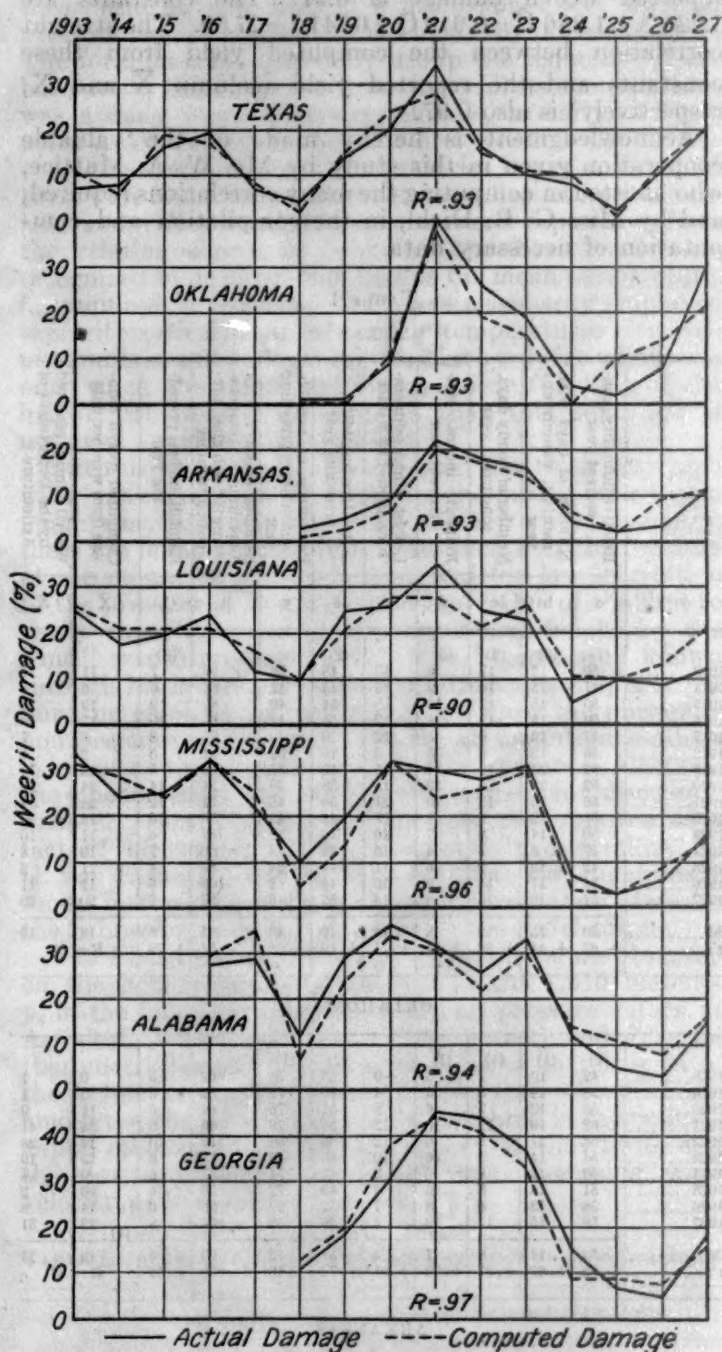


FIG. 1.—Showing graphic relation between the computed damage from weather data by cotton boll weevil for the several States shown in Table 1 (column \bar{X}) and the damage reported by the Department of Agriculture (column X)

number of days with temperature 90° or higher, preceding summer. The multiple correlation between these and reported weevil damage is 0.94. The constants are $1.972 A - 1.445 D + 0.605 E - 0.190 H - 86.40$. The straight correlation between computed damage and reported damage is 0.94.

Georgia.—This State was invaded in 1910 and completely covered about 1917. The period used includes

the 10 years from 1918 to 1927, with first-order station records for Atlanta, Augusta, Macon, and Thomasville. The data used were (a) relative humidity, July and August, concurrent year; (e) lowest winter temperature; (g) percentage of sunshine, July and August, preceding year; and (i) rainfall, July and August, preceding year. The multiple correlation coefficient between these and reported weevil damage is 0.97. The constants are $1.226 A + 1.386 E - 0.910 G + 0.741 I - 27.60$. The straight correlation between the computed yield from these constants and the reported yield (column \bar{X} and X , respectively) is also 0.97.

Acknowledgment is hereby made of the valuable cooperation given in this study by Mr. W. A. Mattice, who assisted in computing the many correlations required, and by Miss G. B. Diehl, in the compilation and computation of necessary data.

TABLE 1
TEXAS

	Relative humidity, concurrent year	Number of days with rainfall, concurrent year	Number of cloudy days, concurrent year	Rainfall, inches, concurrent year	Lowest winter temperature, preceding winter	Relative humidity, preceding year	Percentage of possible sunshine, preceding year	Number of days with maximum temperature 90° or higher, preceding summer	Rainfall, inches, preceding year	Computed weevil damage from weather data	Weevil damage reported by the Department of Agriculture
	a	b	c	d	e	f	g	h	i	\bar{X}	X
1913	(1)	(3)	(3)	(3)		(2)	(4)		(3)	7	7
1914	50	13	17	6	13	48	36	93	7	11	8
1915	47	15	14	9	13	43	42	84	6	6	16
1916	50	15	13	10	18	54	40	82	9	19	19
1917	50	15	12	8	12	54	42	67	10	17	7
1918	43	10	6	5	12	50	40	95	8	8	4
1919	46	12	8	5	3	48	32	91	5	2	14
1920	62	23	19	14	15	42	35	100	5	15	20
1921	52	21	15	12	15	58	50	51	14	24	34
1922	56	16	12	10	21	56	46	71	12	28	18
1923	51	12	8	6	17	48	43	88	10	15	10
1924	50	14	8	7	16	46	38	87	6	11	8
1925	47	9	7	4	15	46	43	80	7	10	2
1926	42	13	9	6	11	44	34	87	4	1	11
1927	54	17	14	9	15	44	42	109	6	12	20
M	50	15	12	8	14	49	40	85	8	13	13
r's	+ .62	+ .44	+ .28	+ .54	+ .71	+ .69	+ .68	-.51	+ .79	R = .93	

OKLAHOMA

	(1)	(1)	(1)	(1)	(2)	(1)	(1)	(1)	(1)		
1918	42	10	7	5	-9	53	78	62	5	0	1
1919	58	14	8	6	4	40	79	82	5	0	1
1920	55	12	7	6	8	51	76	64	6	11	9
1921	62	19	12	10	12	58	76	49	6	38	41
1922	54	11	6	6	12	56	68	72	10	19	26
1923	54	14	5	6	10	50	73	78	6	15	19
1924	52	13	6	6	3	44	74	67	6	0	4
1925	51	14	8	6	4	49	72	70	6	10	2
1926	56	13	6	8	7	52	69	86	6	14	8
1927	58	15	11	10	4	56	58	64	8	22	31
M	54	14	8	7	6	51	72	69	6	15	14
r's	+ .62	+ .60	+ .57	+ .70	+ .61	+ .72	-.46	-.50	+ .54	R = .93	

ARKANSAS

	(1)	(1)	(3)	(1)	(5)	(3)	(2)	(2)	(2)	(2)		
1918	54	11	18	5	-9	64	73	40	9	1	3	3
1919	60	15	20	7	9	60	77	63	5	3	5	5
1920	60	13	20	8	14	65	71	53	6	7	9	9
1921	60	17	19	7	17	65	68	36	8	20	22	22
1922	62	14	17	7	20	67	72	71	8	17	18	18
1923	62	15	17	9	13	69	74	59	6	14	16	16
1924	56	18	17	6	7	66	71	46	6	6	4	4
1925	56	14	15	7	8	61	72	58	5	2	2	2
1926	54	14	17	6	8	65	75	86	7	9	3	3
1927	60	15	23	9	10	59	72	60	9	11	11	11
M	58	14	18	7	10	64	72	57	7	9	9	9
r's	+ .70	+ .65	+ .21	+ .49	+ .71	+ .41	-.47	-.18	+ .34	R = .93		

LOUISIANA

	Relative humidity, concurrent year	Number of days with rainfall, concurrent year	Number of cloudy days, concurrent year	Rainfall, inches, concurrent year	Lowest winter temperature, preceding winter	Relative humidity, preceding year	Percentage of possible sunshine, preceding year	Number of days with maximum temperature 90° or higher, preceding summer	Rainfall, inches, preceding year	Computed weevil damage from weather data	Weevil damage reported by the Department of Agriculture
	a	b	c	d	e	f	g	h	i	\bar{X}	X
1913	(4)	(1)	(4)	(1)		(4)	(1)		(2)	26	25
1914	66	20	39	11	22	70	56	58	12	21	18
1915	66	16	28	10	20	66	66	71	12	21	20
1916	66	12	24	9	18	66	67	76	15	21	24
1917	66	22	24	12	18	66	76	59	13	21	24
1918	60	12	19	7	16	66	64	70	12	16	12
1919	55	13	22	3	3	60	68	56	11	10	10
1920	66	24	35	13	13	55	66	81	10	21	25
1921	65	22	27	13	22	66	56	49	11	28	26
1922	63	21	24	12	25	66	64	46	15	28	35
1923	67	21	26	11	26	63	68	82	10	22	25
1924	66	24	30	14	22	67	66	56	11	26	23
1925	52	10	16	4	13	66	64	46	13	11	5
1926	52	18	30	10	18	52	80	80	4	10	10
1927	60	17	25	8	15	52	68	100	9	13	9
1927	61	22	40	11	20	60	74	82	13	21	12
M	62	18	27	10	18	63	67	67	11	20	19
r's	+ .78	+ .65	+ .28	+ .78	+ .63	+ .43	-.36	-.31	+ .33	R = .90	

MISSISSIPPI

	(2)	(4)	(6)	(4)	(2)	(1)	(4)	(3)	(4)	(3)	(3)
1913	66	36	29	18	23	73	62	37	18	31	33
1914	70	34	35	17	19	66	74	58	18	28	24
1915	66	28	31	17	16	70	78	64	17	24	25
1916	74	36	37	20	18	66	74	48	17	32	32
1917	70	31	31	15	13	74	60	47	20	25	22
1918	56	27	28	14	1	70	76	41	15	5	10
1919	67	34	38	16	10	56	74	60	14	14	20
1920	70	33	42	19	19	67	68	41	16	32	32
1921	64	32	26	14	23	70	72	28	19	24	30
1922	66	31	36	13	25	64	76	71	14	26	28
1923	68	36	41	19	19	66	70	43	13	30	31
1924	54	21	26	9	9	68	74	26	19	4	7
1925	57	28	21	13	15	54	80	65	9	3	3
1926	63	31	30	15	10	57	72	84	13	9	6
1927	60	32	34	15	14	63	78	62	15	15	16
M	65	31	32	16	16	66	73	52	16	20	21
r's	+ .79	+ .71	+ .62	+ .69	+ .74	+ .51	-.44	-.31	+ .42	R = .96	

ALABAMA

	(2)	(2)	(4)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1916	75	25	19	20	15	65	67	63	10	30	28
1917	72	24	15	12	10	75	62	45	20	35	29
1918	56	14	12	8	7	72	62	51	12	7	12
1919	69	24	19	14	9	56	66	58	8	24	29
1920	68	23	20	12	18	69	52	37	14	34	36
1921	63	22	13	10	25	68	54	38	12	31	32
1922	62	17	10	8	25	63	66	89	10	22	26
1923	68	23	16	12	18	62	69	57	8	30	33
1924	56	13	7	6	7	68	62	28	12	14	12
1925	54	14	11	6	21	58	80	71	6	11	5
1926	64	24	18	13	10	54	68	99	6	8	3
1927	60	17	11	8	13	64	66	66	13	16	15
M	64	20	14	11	15	64	64	58	11	22	22
r's	+ .70	+ .69	+ .45	+ .46	+ .37	+ .38	-.55	-.42	+ .40	R = .94	

GEORGIA

	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1918	60	19	15	9	10	72	60	51	10	13	11
1919	70	27	20	14	13	60	69	48	9	20	19
1920	68	27	22	14	17	70	57	40	14	88	31
1921	68	26	18	12	26	68	64	39	14	44	45
1922	67	22	15	8	23	68	60	72	12	41	44
1923	68	21	18	10	20	67	62	50	8	33	37
1924	62	18	12	8	8	68	64	34	10	9	15
1925	54	14	13	5	24	62	76	57	8	9	7
1926	66	25	15	12	12	54	72	93	5	8	5
1927	66	22	12	10	14	66	72	61	12	16	18
M	65	22	16	10	17	66	66	54	10	23	23
r's	+ .60	+ .41	+ .47	+ .23	+ .63	+ .48	-.61	-.20	+ .65	R = .97	

M = Means.
r's = Correlation coefficient between weather data and weevil damage.
R = Gross, or multiple coefficient between weather data and weevil damage.
(1) June and July, combined; (2) July and August, combined; (3) June to August, inclusive; (4) June to September, inclusive; (5) July to September, inclusive; (6) April to August, inclusive.

METHODS AND RESULTS OF DEFINITIVE AIR-PRESSURE MEASUREMENTS¹

By DR. H. KOSCHMIEDER, Director

[Staatliches Observatorium, Danzig]

(Translated by W. W. Reed)

I. HISTORICAL

The following air-pressure measurements were made on the Schneekoppe (1,604 meters). The history of air-pressure measurements on mountains reaches far into the past and furnishes much that is worthy of note. Hence there will be given at the outset a brief historical review, which will best make clear to those who are not meteorologists the difficulties and problems in air-pressure measurements on mountains.

Soon after Torricelli's famous experiment in the year 1644 there followed the first air-pressure measurement on a mountain, which was made by Pascal, through Perrier, on the Puy de Dome on September 19, 1648. The observation gave the result expected by Pascal, namely, that the barometric height decreased with increasing elevation of the point of observation and again reached its former reading when the barometer was returned to the original elevation. Through this result Pascal had at hand a new proof of the incorrectness of the "horror vacui" and proof of the correctness of his view on pressure—"it is certain that very much more air lies at the foot of a mountain than at its summit"—as written to Perrier in a letter published not long ago. The boldness of Pascal's view appears from the same letter in which he emphasizes the words "we must not lightly set aside fundamental principles held from early times unless we are forced thereto by convincing and irrefutable proof." Through the experiment Pascal was now in possession of the proof. The significance of his results is best shown by the improvement made in the physics of measurement in the decades following and the resultant laws of gases.

The hypsometric formula was derived by Halley in 1686, but consideration was first given to the influence of the temperature of the air by Kästner in 1775. In substance, Kästner's formula still serves in practical reckoning. The final step in the development was the hypsometric formula derived by Laplace in 1805. Laplace proceeded from the basic equation:

$$(1) -dp = g\rho dz,$$

in which p indicates the pressure, ρ the density, g the acceleration of gravity, and z the vertical coordinate, positive upward. Herein Laplace introduced the density as a function of the temperature t , the pressure p , and the vapor pressure e . An approximation to the integral is:

$$(2) \log \frac{p_1}{p_0} = -\frac{1}{18400} \cdot \frac{1 - 0.377 \left(\frac{e}{p}\right) m}{1 + \alpha t_m} \cdot (z_1 - z_0)$$

This relation permits the calculation of:

$z_1 - z_0$, when p_1 , p_0 , t_m , and e_m are measured. (Case a.)

p_0 , when $z_1 - z_0$, p_1 , t_m , and e_m are measured. (Case c.)

t_m , when $z_1 - z_0$, p_1 , p_0 , and e_m are measured. (Case c.)

and, indeed, this formula has all three applications in abundant measure.

In the years following, the formula was taken over by those who have to deal in a professional way with air pressure measurements, thus chiefly by meteorologists. The formula came into daily use in the reduction of the barometric height to sea level (case C) as soon as there was a daily weather service, that is, as early as 1863, when LeVerrier established the first weather service.

As the first mountain observatories began to function there were found in the observations collected from mountain and valley stations many marked departures from the relation shown in formula (2). Their cause was recognized to lie in the fact that as the mean temperature, t_m , required in reduction there was necessarily employed the arithmetical mean of the air temperatures observed at mountain and valley stations, which value is admissible only when the temperature is a linear function of the height. It frequently happens that this condition is not even approximately fulfilled.

But this was not all. It appeared that with very high wind velocities, such as occur for the most part only on mountains, but are observed there very frequently, there are found regular departures such that the pressure at the mountain station is measured too low in relation to the pressure at the valley station. One of the first to verify this "lowering of the barometric height by the wind" was Montigny (1851), who became well known through his labors in the field of atmospheric optics. It must be emphasized, however, that when the phenomenon becomes especially noticeable at mountain stations it is not at that time limited to those points. Although the phenomenon was the subject of frequent discussion in later years it first found its final confirmation as a fact of observation through several investigations by G. von Elsner.² The material for these investigations is found in the observations at several mountain stations, the Schneekoppe especially, and on the Eiffel tower.

Von Elsner compared the air pressure values observed on the Schneekoppe (barometric height 1,610 meters), p_s , in the following table, with the air pressure values at Arnsdorf (barometric height 454 meters) and Zillertal (barometric height 397 meters) reduced to the level of the Schneekoppe, p (reduced). He then obtained the amount of the lowering of values measured in the Schneekoppe relative to the values reduced to that level, and this lowering clearly increased with increasing wind velocity as is shown in Table 1.

TABLE 1.—Wind velocity and lowering of pressure on the Schneekoppe

	Wind velocity in meters per second						
	0	11	15	18	22	27	32
Difference in pressure, observed—reduced, mm.	0.1	0.1	-0.3	-0.7	-1.0	-1.5	-2.0
Number of observations	12	350	317	213	141	137	47

In order to meet at once the objection that the derived departures might be a result of insufficient determination of the mean air temperature used in the reduction,

¹ Author's abstract of Methoden und Ergebnisse definierter Luftdruckmessungen. Forschungsarbeiten des Staatlichen Observatoriums, Danzig. Heft I. Danzig, 1928.

² Abhandlungen des Preussischen Meteorologischen Instituts, Bd. IV, Nr. 8. 1913. Meteorologische Zeitschrift, 1926, p. 201 and 1927, p. 99.

von Elsner compared the corresponding values at two elevations on the Eiffel Tower 50 and 313 meters, respectively, above sea level, and found the fully concordant result given in Table 2.

TABLE 2.—Wind velocity and lowering of pressure on the Eiffel Tower (313 meters above sea level)

	Wind velocity in meters per second				
	20.0- 0.9	20.0- 21.9	22.0- 24.9	25.0- 29.9	30.0
Difference in pressure, observed—reduced, mm	0.1	-0.3	-0.6	-0.8	-0.9
Number of observations	60	49	29	13	3

Now the values here given are mean values, whose origin is always difficult to discover. Therefore, Von Elsner adduced examples of convincing individual cases, one of which is given in Table 3.

TABLE 3.—Wind velocity, pressure, and temperature on the Schneekoppe, August 23, 1922

	2 p. m.	3 p. m.	4 p. m.	4:45 p. m.	5 p. m.	6 p. m.
Wind velocity (m. p. s.)	18	20	25	33	31	24
Difference in pressure, observed— reduced, mm	-0.9	-1.0	-1.3	-3.4	-3.1	-1.6
$\frac{1}{2}(t+t_0)$, °C	14.8	14.1	11.7	11.1	10.9	10.0
t_m	11.0	10.0	6.8	-0.1	0.5	4.4
$\frac{t_0+t_m}{2}-t'_m$	3.8	4.1	4.9	11.2	10.4	5.6

In the foregoing table t'_m is the calculated mean temperature. (Case c.) The values in the last line are the errors that would be made by using the arithmetical instead of the true mean of the temperature, provided p_s is correctly measured. According to our present knowledge of the thermal structure of the atmosphere such temperature errors are to be considered out of the question.

By these investigations the "lowering of the barometric height by the wind" was verified as a fact of observation. There remained the question of its explanation.

Von Elsner expressed the opinion that the suction effect of the wind on the building housing the barometer appeared to be the most probable cause. A theoretical explanation of this phenomenon was given by another, but I was able to show³ that in it the integrals of the equations of motion which relate to a stream line were erroneously related to the vertical. Thus far we have considered the historical march of development, to which I will now add my investigations.

II. DEFINITIONS AND PROBLEMS

For the sake of convenience some definitions may well be introduced.

The pressure may be designated briefly as *static pressure* \bar{p} when the pressure decrease in the vertical is determined only by the distribution of air masses in the vertical. This is the case in quiet air or in air moving without acceleration, horizontally, and in a straight line, irrespective of the values that the wind velocity may have in the different stream channels. Here \bar{p} is a function of the height (z) alone, and there holds the equation:

$$\frac{d\bar{p}}{dz} + g\rho = 0$$

The pressure may be designated briefly as *dynamic pressure* \tilde{p} when the pressure decrease in the vertical is not determined by mass distribution in the vertical alone. This is the case just so soon as the rectilinear, unaccelerated movement of the air is disturbed by any obstruction whatsoever. Then in general \tilde{p} is a function of all three coordinates and there holds the equation:

$$\frac{\delta\tilde{p}}{\delta z} + g\rho \neq 0$$

In general, rectilinear, unaccelerated wind movement, and, with it, static pressure within the limits of the accuracy of pressure measurement, may be assumed over a plain. Accelerated movement and with it dynamic pressure effects are brought about (or shown in the record—Translator) (1) by all mountain barriers, (2) by the building that houses the barometer, and (3) by the pressure-measuring apparatus and even by the pressure-decreasing apparatus. The disturbances of the pressure and velocity fields produced (or indicated—Translator) by these three hindrances will be designated as orographic, building, and instrumental.

The instrumental disturbance necessitates the use of a pressure-decrease apparatus in addition to the barometer. With the aid of this it is possible to eliminate the instrumental disturbance. Through a further following of this idea the disturbance caused by the building can be segregated.

The disturbance due to the building is of importance, since up to the present the measurement of pressure has always been made with a barometer suspended in a building. While in the absence of the building the pressure in a space about ten times the size of the building is (even on mountains) evidently a function of the height alone, through the building disturbance it evidently becomes a function of all three coordinates in the vicinity of the building.

The pressure measured in the building itself is plainly a mean value; this is due to the fact that there takes place an equalization of pressure through every opening of the room in which the barometer is exposed. The greater the amount of opening $\Delta\rho$ permitting an equalization of pressure, the greater the weight of the pressure \tilde{p} at the point $\Delta\rho$ in determining the mean, so that the pressure measured in a room p_s is represented by:

$$p_s = \frac{\sum \tilde{p} \Delta\rho}{\sum \Delta\rho}$$

in which the sum is to be taken over all openings permitting equalization. Naturally, such openings are always present, but the geometrical arrangement is entirely a matter of chance and can by no means be taken into the calculation (windows, doors, chimneys, etc.). The geometrical arrangement changes from one observatory to another; indeed, at one observatory it will not be the same through the year (deposit of silver thaw, etc.). From what precedes it is seen that so soon as the building disturbance becomes noticeable the pressure measurement in a room gives a mean value that is in general not correctible; that is, it is no longer definitive. There is further complication due to the fact that a given geometrical arrangement can give very different effects with different wind directions.

In contrast to the first two disturbances the *orographic disturbance* can not be eliminated. As the result of this disturbance the pressure in a widely extended region, many times as large as the area covered by the mountain,

³ Meteorologische Zeitschrift. 1926, p. 246.

is a function of all three coordinates of space. There are, perhaps, marked pressure differences between windward and leeward sides and more or less periodic pressure oscillations to leeward. However, the processes on the lee side are to be given notice merely as regards characteristic features, so it will be well to pass over this matter of uncertainty. By pressure on a mountain summit there will be understood that pressure which is measured at the earth's surface, on the windward side, and in closest proximity to the summit.

There is now the two fold problem: (a) To indicate a practicable method of measurement which will permit continuous definitive measurement, and (b) to determine quantitatively the building and the orographic disturbances.

III. METHOD OF MEASUREMENT

After several futile attempts I solved the first problem by recourse to a very simple pressure-decrease apparatus. A flat, circular plate, 28 cm. in diameter, was perforated at the center and into the perforation there was carefully inserted a small tube 3 mm. in diameter; the plate was then placed on the ground over a water drain. The opening of the plate was connected through a tube 8 mm. in diam-

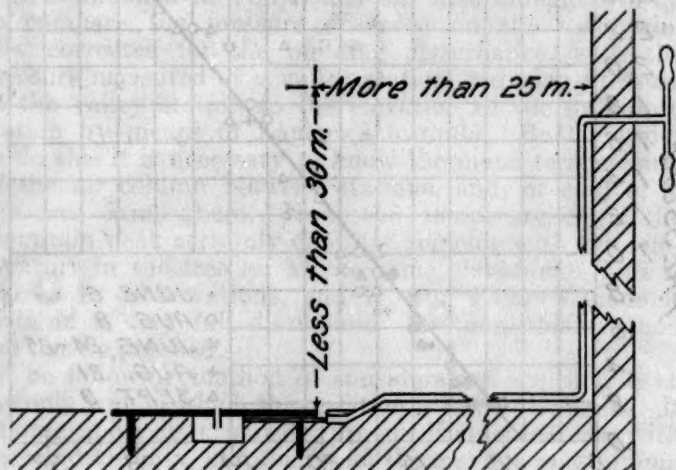


FIG. 1.—Pressure-decrease apparatus

eter and about 60 m. long (inside a drain pipe) with the interior of an aneroid box placed in the barometer room.

If there occurs in the room a fall or rise in pressure relative to the pressure at the opening in the plate then there follows a bending of the aneroid box, the amount of the bending furnishing a measure for the pressure deficit or pressure excess in the room. This bending can be recorded; and for this purpose I used an ordinary commercial pressure-difference recorder which was kindly placed at my disposal by the Askania factory in Berlin.

The system described⁴ has two important advantages: (1) The pressure-decrease apparatus has no movable parts, a feature of importance in securing continuous functioning; and (2) the opening is in the stratum of lightest wind, a condition that is of importance in accuracy of measurement.

In my full publication⁵ there is discussion in detail of six possibilities of error and it is shown that the total error in the measured pressure differences does not exceed 0.2 mm., even with a wind velocity of 30 m. p. s. at the height of 2 meters above the ground.

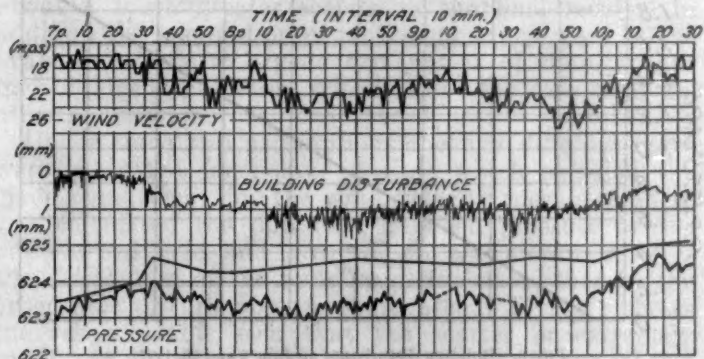
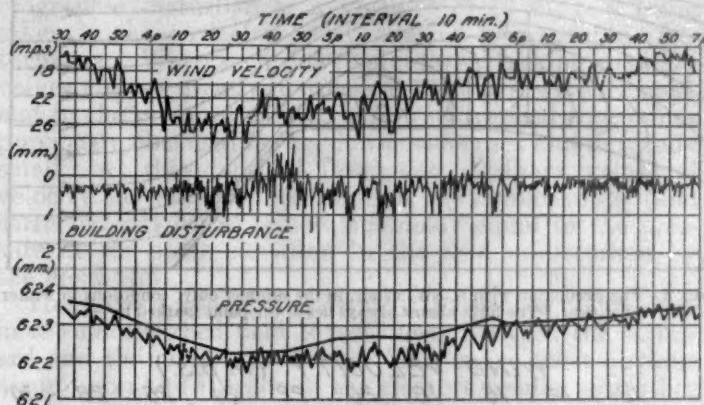
⁴ The possibility of this system was pointed out, independent of myself, by O. Schrenk in the *Meteorologische Zeitschrift*, September, 1927. It was used in my measurements as early as April, 1927.

⁵ Methoden und Ergebnisse definierter Luftdruckmessungen. Forschungsarbeiten des Staatlichen Observatoriums, Danzig. Heft. I. 1928.

IV. BUILDING DISTURBANCE

The measurements show two cases: (a) With SSW. to SW. winds the building disturbance is practically negligible, with changing sign of departure, and there is no agreement with the march of wind velocity (fig. 2), and (b) with WSW. to NNW. winds it is, on the contrary, noticeable, the pressure difference between the room and the circular plate (deficiency of pressure in the room) showing even in small details a change from time to time paralleling the change in wind velocity (fig. 3, wind up to 7:30, SW.; thereafter, a change).

With measuring arrangement unchanged, case a changes to case b as soon as the wind changes from SW. to WSW.-NNW., and vice versa. Figures 2 and 3 give an example of this.



FIGS. 2 and 3.—Wind velocity, building disturbance and atmospheric pressure 3:30 to 7 p. m., and 7 to 10:30 p. m., respectively, on June 8, 1927

The different behavior of the building disturbance is explained by an observation which I owe to the observer at the Schneekoppe, whose presentation is reproduced unchanged in Figures 4 and 5.

With WSW.-NNW. winds (fig. 4) the building and the anemometer exposed on its roof lie to the windward of the mountain in a steadily directed current; on the contrary, with SSW.-SW. (fig. 5) winds the building now lies, in a current so extremely shifting that there can be no thought of a real wind direction, while the anemometer is found in the SW. current. Agreement can not be expected between the wind velocity measured in the steady SW. current and the building disturbance produced by the altogether unsteady current. The fact that with SSW.-SW. winds the building disturbance remains small is readily understood in view of the continual change in wind direction in the immediate vicinity of the building.

Figure 6 shows the dependence of the building disturbance on the velocity of the wind. In it we see that

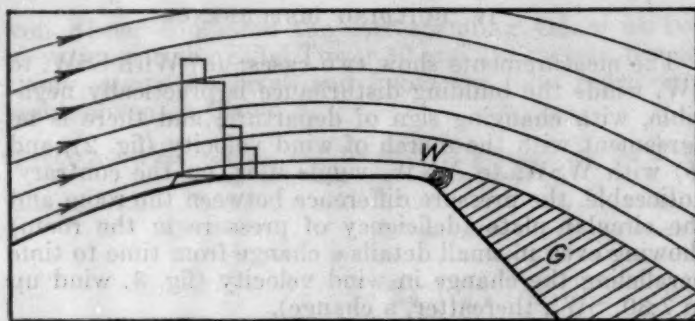


FIG. 4.—Fog circulation with N.-NW. winds; whirl found only at W. In the space G, wind direction mostly downward, rarely upward

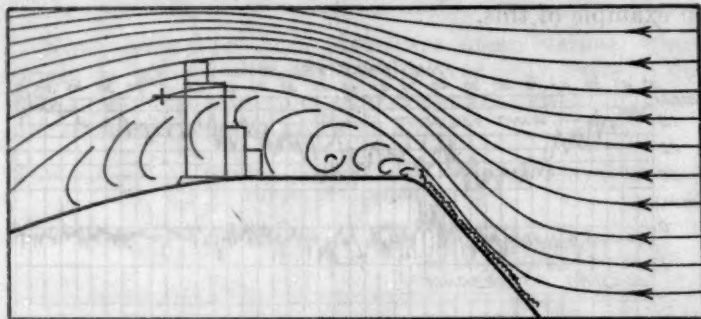


FIG. 5.—Fog circulation with S.-SW. winds, in the summer only; conditions in winter not clear. The limit almost always lies at the point marked by +.

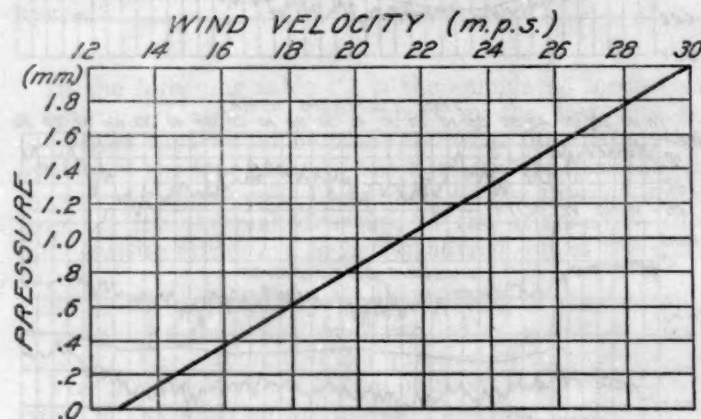


FIG. 6.—Building disturbance on June 8 and 20, 1927

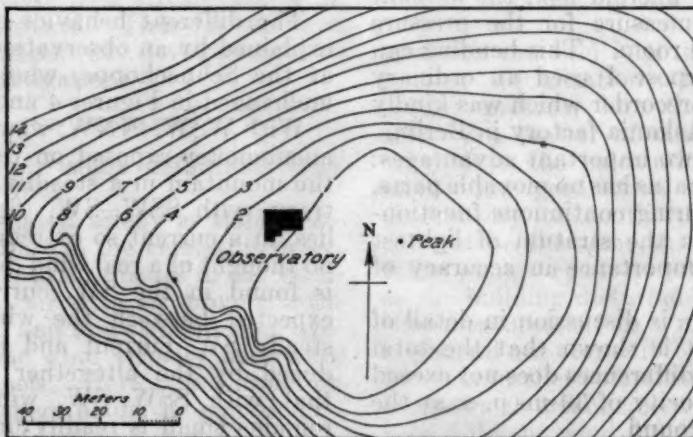


FIG. 9.—Contour map of the Schneekoppe

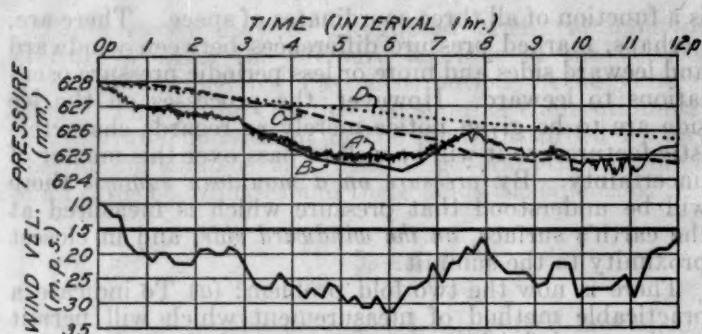


FIG. 7.—Pressure and wind velocity on September 9, 1927

- A. Pressure in room (barograph)
- B. Pressure corrected for building disturbance
- C. Pressure reduced from Arnsdorf (static condition)
- D. Pressure in the undisturbed field (free air)

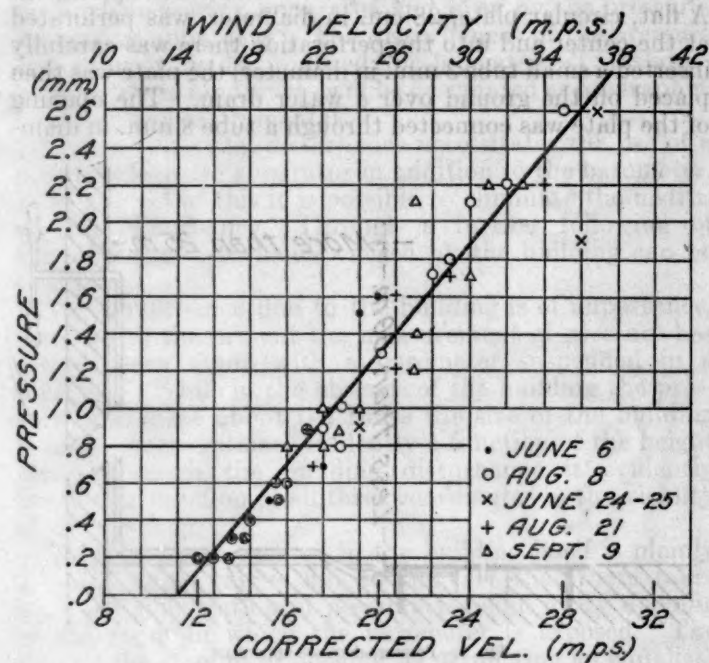


FIG. 8.—Orographic disturbance

this disturbance is practically unnoticeable for wind velocities up to 14 m. p. s., but amounts to 2 mm. with a velocity of 30 m. p. s. (In the reproduction the details of the original have been omitted.)

The fact that the building disturbance can reverse the sign of the pressure change is of special importance in meteorological questions. In several instances it could be shown that with increasing wind velocity there was, after the elimination of the building disturbance, a pressure rise, while the barograph in the barometer room traced a marked fall.

V. OROGRAPHIC DISTURBANCE

An obvious proof of the existence of an orographic disturbance is, strictly speaking, possible only when comparison is made between pressure values on a mountain and pressure values actually measured in the immediate vicinity, at 10 to 20 km. distance, at the same elevation in the free air. A rather long time will pass before the meteorologist is given the opportunity to make such a comparison. In order to arrive at results in this direction the question must be approached in a different way.

In common with Von Elsner our first thought will be to compare the pressure observed on the mountain, now corrected for the building disturbance, with the pressure measured at a valley station, reducing pressure at the valley station to the elevation of the mountain station by means of Laplace's formula. But in order to do this it is necessary to know the mean temperature of the air column between stations, and, of course, in the free atmosphere. Now the temperature on the mountain peak certainly does not coincide with the temperature in the free air at the same elevation. This is proven by observations, and H. von Ficker⁶ made it plain in a very full discussion. So then this method can not be pursued.

The following method of consideration appears to be the only way in which the question is to be discussed. If an orographic disturbance is present it must increase with the wind velocity, and then, too, the maxima and minima of pressure and velocity must occur exactly simultaneously and in opposite sense. If, on the other hand, there is a pressure disturbance which is caused by distribution of masses and, thus, is not connected with the locality, but occurs also in the undisturbed field (the free air), then the extremes of pressure and velocity must show a shifting of phase such that the maxima of velocity and the maxima of pressure change will coincide. (Of course the highest velocities are expected to be encountered during pressure rise and conversely.)

Since the meteorologist knows of no relation between wind velocity and pressure, but knows of a very decided relation between wind velocity and pressure gradient—that gradient which, to give a first approximation, is found in the direction at right angles to the current direction in the horizontal plane. (Coriolis' law.) The relation between wind velocity and pressure gradient is manifest on every weather map; at the center of the low pressure region there can be found for the most part weak winds and on the border, on the contrary, strong to stormy winds. Now, if we substitute for the conditions that are adjacent in point of space those that succeed them in point of time, there results the statement expressed above.

In this direction detailed investigation was made of five individual cases, one of which is reproduced in

Figure 7. This shows plainly that the pressure and velocity curves present the same phases and that the maxima of wind velocity coincide with the minima of air pressure. In this we have demonstration of the orographic disturbance.

We come now to the question of the quantitative determination of the orographic disturbance $p - p_0$, that is, the determination of the difference between pressure in the undisturbed field, the free air, p_0 and the pressure on the mountain peak, building disturbance having been eliminated, p . This determination is made here under two assumptions. The first assumption is that the pressure on the mountain peak is at the most just as high as the pressure in the undisturbed field. There were selected those velocity values at which the force of the wind is certainly too low to produce a noticeable orographic disturbance, a velocity of 12 m. p. s. being taken as the critical velocity relative to orographic disturbance. When such (low) values were lacking auxiliary values not too greatly in excess of 12 m. p. s. were selected, and to the pressure values there were applied corrections previously obtained for the lower velocities and naturally small. At the standard (low) and auxiliary values of velocity the pressure observed on the Schneekoppe (and corrected but little) is now obviously equal to the pressure at the same elevation in the field undisturbed by the mountain.

The second assumption is that the course of pressure in the undisturbed field is rectilinear between the standard and the auxiliary values. This is the most obvious assumption and it leads to the clearest results. Another assumption probably suggests itself, yet it would bring about a much greater scatter in the final result. In addition the assumption of rectilinear course used in the evaluation leads to a good explanation of simultaneous meteorological processes, which is not the case with the other assumption.

Under these two assumptions the five different cases were evaluated for points of time which satisfied the given conditions; for the wind velocity measured there was calculated the difference between pressure in the undisturbed field and pressure on the mountain after the elimination of the building disturbance, that is, the orographic disturbance was segregated. Figure 8 shows the result. It is seen that the scatter is extremely small, which argues well for the working hypotheses introduced. Figure 8 also shows that under the assumption that 12 m. p. s. is the critical velocity, the orographic disturbance on the Schneekoppe, with winds from SSW.-SW., amounts to about 1 mm. for a velocity of 18 m. p. s. and to about 2 mm. for a velocity of 25 m. p. s.

There is yet a word to be said with reference to the relation between building and orographic disturbances. With SSW.-SW. winds there occurs no noticeable building disturbance, while there is a marked orographic disturbance. On the other hand, with WSW.-NNW. winds there appears no noticeable orographic disturbance, while there is a marked building disturbance. With a wind velocity of 30 m. p. s. the building and orographic disturbances differ by as much as 30 per cent, but the order of magnitude is always the same. There is, therefore, the inclination to suspect some error. The question was debated carefully, but had to be answered in the negative.

The difference is to be explained by the topography of the Schneekoppe. (Fig. 9.) The steepest slope of the peak is that toward the southwest, therefore the oro-

⁶ Meteorologische Zeitschrift, 1913, p. 278.

graphic disturbance will be at the maximum with SW. winds. On the other hand the building then lies on the lee side and the building disturbance becomes unnoticeable. Toward WSW.-NNW. winds the peak presents a slope that is considerably less steep, and the orographic disturbance becomes very small. On the other hand the building now lies to the windward and the building disturbance can become quite marked.

VI. SIGNIFICANCE OF RESULTS

In conclusion something may be said relative to the significance of the results. One who is not a meteorologist will very properly raise the question: Have these pressure differences of 1 to 2 mm.—that is, 2 to 4 per cent of error in observation—really such significance that a paper such as this should be devoted to them? The meteorologist will answer in the affirmative on these grounds.

1. The investigation gives for the first time a measure of the accuracy of air pressure determination and shows that building and orographic disturbances in the cases

here cited can amount to twenty to thirty times the probable error in daily observations.

2. Building and orographic disturbances have the appearance of indications of a pressure tendency in the undisturbed field (the free air) which can be opposite to the true pressure tendency. This knowledge is of significance in the explanation of meteorological processes.

3. At present pressure observations at mountain and valley stations are used to determine the mean temperature of the air column below the mountain station. (Case c.) Now on the Schneekoppe an error of 1 mm. in the pressure measurement—and this frequently occurs—corresponds to an error of 3° C. in mean temperature. That this is a rather large value is learned from the fact that through more than a decade there was carried on a controversy as to whether or not the temperature on a mountain peak is 1° to 2° C. lower than the temperature in the free atmosphere at the same elevation; that is, whether or not the mean temperatures of the columns of air differ from each other by 0.5° to 1.0° C.

Herewith there is adduced proof that considerable significance attaches to the results.

THUNDERSTORMS IN THE LOS ANGELES DISTRICT

By CHARLES CLIFFORD CONROY, Ph. D.

(Author's abstract)

Since January 1, 1884, 164 days with thunderstorms have been noted in Los Angeles, and 52 others have been recorded in the immediate vicinity. The monthly distribution of these storms is interesting. March is the month of greatest frequency, followed in turn by April, January, September, February, May, August, July, June, October, November, and December. Seasonally, the minimum belongs to the last three months of the year. There is a secondary minimum in June, and a secondary maximum in late August and September. By 3-month periods, January, February, and March, have 36.5 per cent of all the storms; April, May, and June, 26.2 per cent; July, August, and September, 24.5 per cent, and October, November, and December, 12.8 per cent. The first half of the calendar year has 62.2 per cent, and the second half has 38.8 per cent.

The hourly distribution shows a maximum at 3 p. m., and a minimum at 6 a. m. There is a secondary maximum at 3 a. m., a fact somewhat suggestive of oceanic influence. The yearly numbers of storms vary from 10 in 1919 to none in 1891 and 1915. Periods of pronounced frequency occurred in the four years 1905-1908, the three years 1918-1920, and in 1926-27. On the other hand, no thunderstorms at all were recorded from January 27, 1914, to September 30, 1916. The data at hand furnish no conclusive evidence of any progressive numerical increase of thunderstorm activity in the Los

Angeles area. Nor is there any evidence of a relationship of local thunderstorm frequency to the sunspot period.

Three types—not mechanical, but types of occurrence—may be distinguished: that of the winter, when the thunderstorm takes place at the end of a pronounced disturbance, and along a windshift line, or when local convection occurs during a heavy winter rain. A second type depends upon the presence of a low-pressure area whose center is on or near the Mexican line. Los Angeles is then at or near the northern limit of such areas, and the barometer is unsteady. The third, or summer type, depends upon the well-known "Sonora" condition, and is especially evident when the center of the Colorado River "low" is somewhat northwest of its usual place and when a second "low" is mapped over Oregon or southwestern Idaho. The temperature and humidity are often quite high, even after the storm.

Of the entire list of 164 thunderstorm days, only some 20 afforded fairly severe storms, and only one—or rather the series of storms on June 30-July 1, 1918—can be described as violent. Some minor damage has been recorded in the city twenty-five times. Of late years, however, petroleum tanks have been struck and destroyed in different parts of California, and this is at present the principal problem in the prevention of destructive effects.

THE MECHANISM OF A THUNDERSTORM

By G. C. SIMPSON

[Reprinted from Quarterly Journal Royal Meteorological Society, vol. 54, p. 155, Meteorological Office Abstracts, 1927, No. 892]

Starting from his breaking-drop theory of the origin of electricity in thunderstorms and making use of the further meteorological knowledge of storms which has accumulated since 1909, Doctor Simpson has set out in the present paper, qualitatively and quantitatively, the complete theory of the thunderstorm.

Two diagrams¹ are first given showing the structure of the thunderstorm. The first figure shows the thundercloud in vertical section. The stream lines of the air flow enter the storm, passing under the forward end of the

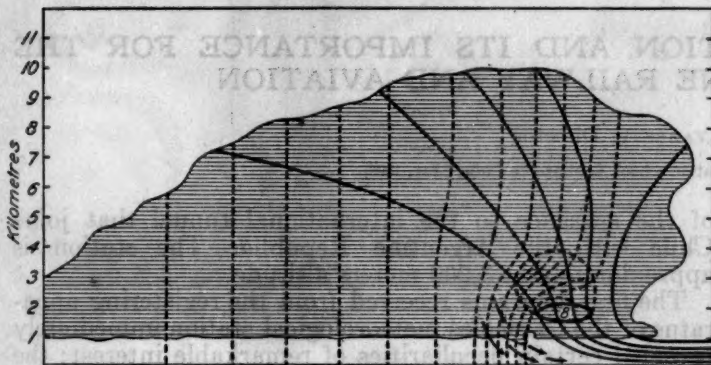


FIG. 1

cloud, and then rise into the cloud. The stream lines then spread out into the body of the cloud. The region where the vertical component of the rising air is more than 8 meters per second is marked. No rain can descend through this region, as the upward velocity of the air exceeds the terminal velocity of the largest possible stable raindrop (0.5 cm. diameter). Dotted lines show the course taken by falling raindrops in various parts of the cloud. In the rear parts of the cloud the rain falls almost

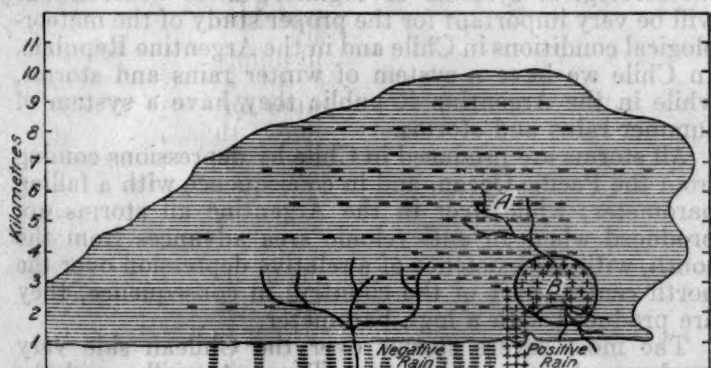


FIG. 2

vertically. In the front parts of the cloud the rain is deflected toward the rear by the air stream, the magnitude of the deflection depending on the size of the raindrops. Over the region of maximum vertical velocity there will be accumulation of water. The largest drops will fall as the bounding surface of that part of the cloud where the vertical air velocity is 8 meters per second. Here they will be broken up and the little drops produced will be carried up again. They will recombine, descend again, and the process will be repeated, and so on.

The second diagram exhibits the electrical distribution produced by this set of conditions. In the region where breaking up of drops is taking place the water receives a positive charge and the air a negative charge. This negative charge is carried away into the main body of the cloud by the air current. The accumulating water soon becomes highly charged positively. The heavy rain which falls to the rear of the region of breaking drops is thus predominately positively charged and the lighter rain falling from the rear of the main cloud is preponderantly of negative charge.

The second diagram also shows the characteristics of the lightning to be expected according to this theory. The main discharges start in the region where water is accumulating; that is, in the seat of the positive charge in the cloud. They branch upward into the main body of the cloud and downward toward the ground. It may also happen that there may be a strong enough field built up between the negatively charged part of the cloud and the earth. In this case a discharge starts on the ground and branches up into the cloud.

The next step is the examination of the theory to see if the quantities involved are all of the proper order of magnitude and whether the phenomena as a whole are in accordance with observation. First of all, the electrical quantities involved are examined. The necessary simplification is secured by assuming the region of accumulating water, and hence of positive electricity, to be a sphere of radius 1 kilometer and with a center 3 kilometers above the ground. The region of negative electricity is represented by another sphere, 3 kilometers radius, and center 7 kilometers above the ground. This latter sphere is vertically above the positive sphere and hence the two are tangential. In order to approximate to the nonuniformity of the distribution of electricity, each main sphere is divided into four smaller spheres, each of which is given an appropriate volume charge.

From these assumed data the field at any point due to the charges can be calculated. The total charge upon each set of spheres is 100 coulombs, this figure being suggested by some of Wilson's results. The distribution of volume charge as between the four spheres comprising each region is made upon a very likely basis, with a number of variants of position in the case of the positive spheres. In the three cases examined two had a sufficiently ample potential gradient to initiate a discharge.

The next question to be considered is whether there is sufficient breaking of drops to produce the required quantities of electricity. A direct calculation is out of the question, but an estimate can be found by considering the amount of electricity which has been found to be brought down by the positively charged rain. In some observations made at Simla this varied from 0 to 7 e.s.u. per cc. The order of magnitude may be taken as 1 e.s.u. per cc. On this as a basis, the 100 coulombs of electricity signifies that the amount of water present in the positive region is about 3 by 10¹¹ grammes. Spread uniformly over the cross section of the region, this will yield a layer of water 10 cm. deep, a very possible amount of water from a meteorological point of view. An estimate of the time needed for such an amount of water to accumulate works out at 17 minutes, a reasonable period. Also an estimate of the amount of electricity produced if all drops available for breaking broke simultaneously

¹ Both diagrams are reproduced from Proceedings Royal Society of London, volume 114, series A, 1927, pp. 377 and 379.

is 3.5 coulombs. Ten breakings would thus produce 35 coulombs, the average amount required for an average lightning flash, again a reasonable result. Thus the proposed theory is in conformity with the facts and the amount of breaking of drops and the quantities of electricity involved are not out of harmony with what might be expected from observed facts.

The three possible types of lightning discharge are denoted as follows:

(1) Discharge from the seat of positive charge upward into the cloud—type U.

(2) Discharges downward from the same region—type D. These may be further subdivided into types D₁ and D₂, according as to whether the discharge reaches the ground or not.

(3) Discharges from the ground up to the negatively charged cloud—type N.

Schonland and Craib, from their observations of storms and the field changes resulting upon the lightning discharges, arrived at conclusions which they thought to be definitely inimical to the breaking drop theory. Doctor Simpson reexamines their results and finds that the discrepancy is due to the fact that Schonland and Craib ignored the possibility of a lightning flash directed downward toward the ground, but failing to reach the ground (i. e., type D₂). Taking this important point into consideration, it is shown that the results of Schonland and Craib and Wilson fit excellently with the present theory.—*C. E. Britton.*

THE CARACOLAS METEOROLOGICAL STATION AND ITS IMPORTANCE FOR THE TRAFFIC OF THE TRANSANDINE RAILWAY AND AVIATION

By JULIO BUSTOS NAVARRETE, Director

[Observatorio del Salto, and professor in the aviation school, Santiago de Chile, May, 1928]

The great storms that frequently blow, year after year, over the Andes Mountains have not been properly studied, and all the observations available, as force of the wind; nebulosity; amount of clouds, forms, velocity, and direction; visibility; height of snow; rainfall and hydrometeors, where only dispersed observations were made by different persons. The need for scientific data about the storms over the Andes Mountains has been clearer since Transandine Railway and aviation require to be in possession of reliable facts about the weather, not only for the development of their traffic but also before crossing over on each passage.

At the beginning of the year a letter was written from the Observatorio del Salto to the manager of the Transandine Railway Co. asking them for their cooperation in the installation of a meteorological station in Caracoles. As the railway company is the most affected by the storms on the cordillera, our solicitude was favorably acknowledged and the necessary instruments for the installation were immediately bought.

The Caracoles meteorological station was finally installed on the 15th of May; and by its instruments as well as by its position it is called to provide observations of great interest. The meteorological shed or pavilion is located near the Caracoles Railway station and it is formed by double-latticed sides to prevent the snow from getting in, and it is also 4 meters from the ground, to prevent it being covered by the great snowstorms. Inside there is a Lambrecht meteorograph apparatus of high precision, which was previously controlled by comparing it with the standard instruments of the Observatorio del Salto. This apparatus gives a continuous record of the pressure, temperature, and humidity. The pluviometer is located at a certain distance away from the railway station and the vane is on the station itself.

The following observations are made daily and transmitted by telegraph to the Observatorio del Salto: Atmospheric pressure, reduced to sea level; relative humidity; temperature of the air, maxima and minima; wind's direction and force; clouds, amount, forms, velocity, and direction; visibility; height of snow; rainfall; hydrometeors.

It remains for us to say that the Caracoles meteorological station is situated on the highest point of the Transandine Railway, near the Cumbre, and at the side

of the entrance to the international tunnel that joins Chile with the Argentine Republic. The station is approximately at 3,200 meters altitude.

The first diagrams received from the registering apparatus of the Caracoles meteorological station immediately revealed certain peculiarities of remarkable interest; the oscillations of the atmospheric pressure are not simultaneous with those of the central zone of Chile; they produce themselves 24 hours later, and seem to be intermediate with those of the Argentine Republic; the oscillations of the temperature exceed the values which had been estimated for them before. For example, on the week from the 14th to the 21st of May, minima of 15° C. below zero were registered, etc.

In our monthly bulletin we will publish a résumé of the meteorological observations of the Caracoles station, which, as before stated, is situated on the limit of two meteorological systems or régimes; these observations will be very important for the proper study of the meteorological conditions in Chile and in the Argentine Republic. In Chile we have a system of winter rains and storms, while in the Argentine Republic they have a system of summer rains and storms.

All storms are produced in Chile by depressions coming from the Pacific Ocean, and in consequence with a falling barometer; while over in the Argentine all storms are produced when an anticyclonic area advances from the south, with the existence of a relative depression over the north central part of the country; in consequence, they are produced with a high barometer.

The most severe storms over the Chilean side very rarely reach any farther than Tierra Amarilla, and the most intense Argentine storms scarcely come any farther this way than Juncal. The greater part of the water vapor condenses and precipitates itself over the cordillera.

Serious doubts have risen regarding the displacements of the depressions. Not long ago, it was discussed, if the depressions that come from the Pacific Ocean, that affect Chile's central zone, could really cross over the cordillera, and influence the weather over Argentine's central zone; nevertheless, the Caracoles observations seem to infer that certain depressions coming from the Pacific Ocean occasionally manifest themselves 24 hours later over the cordillera and afterwards over Argentine's central zone.

M. W. R. October, 1928

(To face p. 313)

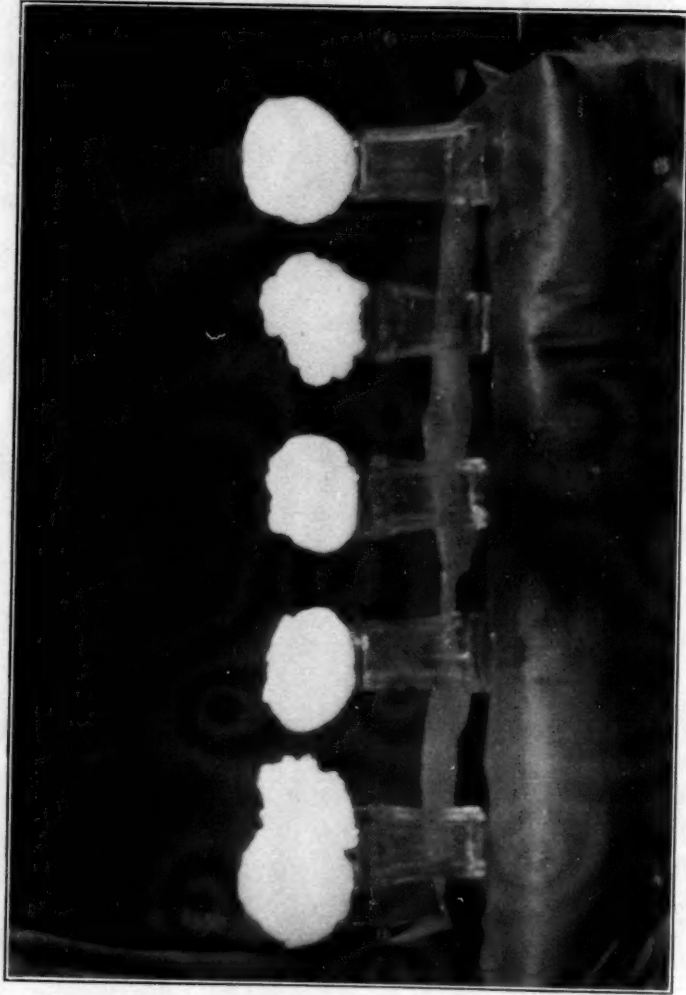


FIG. 1.—Hailstones at Potter, Nebr., July 6, 1928, on 10-ounce glass tumblers. (Photograph by J. J. Norcross)

Finally, this will be a matter of future investigations, as we are not able yet to advance any further on the subject.

Meanwhile the Caracoles observations, together with those of Los Andes and Mendoza, are very valuable and useful. Complete meteorological information and a weather forecast for the subsequent 24 hours are sent daily by cable to the manager of the Transandine Railway. These data are very useful for the Transandine traffic and transportation of cargo.

HAILSTONES OF GREAT SIZE AT POTTER, NEBR.

By THOMAS A. BLAIR

[Weather Bureau Office, Lincoln, Nebr., August 22, 1928]

A remarkable hailstorm occurred at Potter, Cheyenne County, Nebr. (lat., $41^{\circ} 13' N.$; long., $103^{\circ} 18' W.$; elevation, 4,387 feet), on July 6, 1928, during which hailstones "as large as grapefruit" fell, one of which measured 17 inches in circumference and weighed $1\frac{1}{2}$ pounds. This appears to be the largest single hailstone of which there is authentic record anywhere in the world. The largest I have found described elsewhere are by Russell,¹ who tells of a hailstorm in New South Wales in which "some of the stones were said to be 14 inches in circumference," and of three storms in India in which stones measured from 10 to 12 inches.

The following account is given by Mr. H. Stevens, cooperative observer of the Weather Bureau at Potter since 1921 and editor of the weekly newspaper, the Potter Review, in which the article was published, July 13, 1928:

People of Potter and the immediate community will recall the hailstorm of July 6, 1928, for many years to come and will have their narrations of the event disputed on every score. A dark cloud approached from the west and gave the appearance of containing considerable wind. Most people were out watching the progress of the storm, when a peculiar hissing noise was heard in the air and hailstones as large as baseballs began falling at various distances. The hailstones soon increased in size and some were as large as grapefruit, most of them almost round and measuring from 10 to 14 inches in circumference, and weighing from 10 ounces to a pound and a half.

This particular display of the ethereal iceman seemed to center in Potter, the community reporting a slight fall of smaller hailstones. No particular damage was done by this record-breaking hail, except a few roofs were slightly injured, four houses and a garage reporting holes torn through the roof by the gigantic but widely scattered hailstones. We would estimate that about 10 stones fell on each space the size of an ordinary town lot. They fell from 10 to 15 feet apart. The monster chunks of ice could be heard hissing through the air, and when they hit in plowed or soft ground completely buried themselves, and sank halfway in on prairie ground.

In a letter confirming this statement Mr. Stevens gave the following additional description of the appearance of these stones:

The stones, most of which measured around 14 inches in circumference, were smooth, of clear ice, and made up of concentric rings around a single center. Some stones were jagged, having the appearance of one large stone with a number of little stones frozen on its outside.

The following affidavits were kindly obtained by Mr. Stevens from two responsible and conservative citizens of Potter:

POTTER, NEBR., August 11, 1928.

To whom it may concern:

I, J. J. Norcross, proprietor of the Potter Drug Co., do affirm the following facts:

¹ In the book, *On Hail*, pp. 50 to 62, by R. Russell, published by Edward Stanford, London, 1893.

The Latecoere Commercial Aviation Co. has also taken an interest in our Andes Mountains meteorological studies, and, if it is necessary, they are willing to install a new observatory in the interior of the cordillera, farther north, opposite the town of Copiapo. The development of commercial aviation is intimately dependent for its success upon a good service of meteorological information about the weather over the cordillera, thus preventing loss of material and irreparable accidents or disaster.

That on July 6, 1928, following the hailstorm in Potter, Nebr., I gathered several hailstones and measured and weighed them on standard store scales, and that one stone measured 17 inches in circumference and that it weighed $1\frac{1}{2}$ pounds; and that I found another one almost twice as large but was evidently composed of two mammoth stones frozen together. The 17-inch stone was round and hard, with smooth surface, and upon breaking it open I found it was composed of concentric layers built around one center.

(Signed) J. J. NORCROSS.

Subscribed and sworn to before me this 13th day of August, 1928.

[SEAL].

A. J. AMES, Notary Public.

POTTER, NEBR., August 11, 1928.

To whom it may concern:

I, Andrew Anderson, a resident of Potter, Nebr., do affirm that on July 6, 1928, I picked up hailstones in Potter, Nebr., and that one round smooth stone weighed 19 ounces and was 15 inches in circumference. The stone had been outside 10 or 15 minutes before I picked it up, and perhaps had already melted some. Another stone, measured 7 inches from tip to tip, was $4\frac{1}{2}$ inches in diameter at the largest point and about 3 inches in diameter at the small end. From appearances this stone was only a part of a larger stone, it being broken. I would judge the whole stone, if it were intact, the pieces of which were lying around close by, would have been as large as an average man's head.

(Signed) ANDREW ANDERSON.

Subscribed and sworn to before me this 13th day of August, 1928.

[SEAL].

A. J. AMES, Notary Public.

The photograph was taken by Mr. Norcross with the stones resting on 10-ounce glass tumblers, such as are used in soda-fountain service. The stone on the extreme right is that described by Mr. Norcross which measured 17 inches in circumference and weighed $1\frac{1}{2}$ pounds, and that on the extreme left is the one he described as two mammoth stones frozen together. It will be noted that several of the stones, including the 17-inch one, are described as round and smooth, of clear ice, and were found to consist of concentric layers around a single center, showing that they were built up as single stones and not as agglomerations of smaller ones.

The explanation commonly given of the formation of hail assumes that the size of the hailstones is limited by the strength of the upward convection current. This explanation appears insufficient to account for stones of the size of those reported here. No convective updraft would support stones approaching these in size. The fact seems to be generally overlooked that hailstones may grow rapidly while falling. These immense stones probably began to fall when of ordinary diameter but fell through a thick stratum of super-cooled droplets. As they fell they grew with great rapidity by contact with these droplets, which instantly congealed upon them.

THE UPRUSH OF AIR NECESSARY TO SUSTAIN THE HAILSTONE

By W. J. HUMPHREYS

The upward velocity of the air necessary to just sustain a hailstone of a given size often has been computed on this or that set of assumptions. The most doubtful (in fact, distinctly erroneous) of these assumptions, the "drag"—that is, pull plus suction—of a steady wind on a sphere, can now be replaced by actual wind-tunnel measurements made at the Bureau of Standards and elsewhere.

From these measurements made in a steady wind of 150 foot-seconds and kindly supplied by the Bureau of Standards the following table has been computed on the assumptions that the drag varies directly (1) as the density of the air and (2) as the square of the wind velocity, and the further assumptions that (3) the density of the air is three-fifths that at sea level, corresponding to a height of about 5 km., that (4) the density of the hailstone is as given, from 0.91 nearly the maximum possible, to 0.5, certainly close to the minimum, and (5) that the stone is spherical.

Updrafts of air, of three-fifths its sea level density, sufficient to just sustain hailstones

Diameter of stone	Density of stone				
	0.9	0.8	0.7	0.6	0.5
Inches	Miles per hour	Miles per hour	Miles per hour	Miles per hour	Miles per hour
1	62	59	55	51	47
2	89	84	78	73	68
2.5	103	98	91	84	77
3	123	116	109	101	92
3.5	154	145	136	126	115
4	210	198	185	172	157
5	248	234	219	203	185

Hailstones 1 inch in diameter are very common, even on reaching the ground after some melting during their fall. Two-inch stones also are often reported, and even the 3-inch size is not extremely rare. The occurrences in the free air of approximately solid, spherical hailstones 4 inches in diameter is doubtful, though even much larger have been reported. One good reason for this doubt is the surprising experimental fact that the drag of a strong wind is decidedly less on a 4-inch sphere than on a 3-inch one, and not greater in about the ratio of their cross sections (16 to 9), as commonly supposed.

With reference to the navigation of the air, it is obvious from these values that the midst of a cumulus cloud in which large hailstones are being formed is an extremely dangerous place (apart from the lightning hazard and mechanical injuries by the hail) for aircraft of whatever type—a place to be avoided at every cost.

This statement is based on the assumption that the generally accepted theory of the formation of the hailstone (its suspension and uplift by rising currents until full size is attained) is sound.

It has been suggested that the larger hailstones are formed by the capture and freezing of undercooled water in the course of their fall. This may look like a simple way out of the necessity of assuming uprushes of hurricane velocity, but it is not tenable. In the first place we have no evidence whatever of the existence of appreciably undercooled raindrops, and even if they did exist large hailstones could not be formed in the manner suggested.

Suppose, for instance, that there is enough undercooled rain below the falling hailstone to produce a horizontal layer of water an inch deep, certainly an extravagant supposition, and suppose that every drop touched by the falling stone is captured and converted to ice—an unallowable supposition as explained below—what would be the thickness of the shell thus added?

If a is the fraction of the space in the layer of evenly distributed undercooled drops occupied by water, and r_0 the initial radius of the stone, then, clearly, the catch at any stage of the fall, $a\pi r^2 dh$, due to the infinitesimal change of height, dh , is equal to the corresponding volume added, $4\pi r^2 dr$, from which we have

$$dr = \frac{a}{4} dh$$

Hence the thickness of the shell gained by the stone in falling clear through the layer of undercooled rain is

$$r_1 - r_0 = \frac{a}{4}(h_0 - h),$$

in which h_0 and h are the heights of the top and bottom, respectively, of this layer.

But, according to the above assumption, the undercooled rain through which the stone falls is sufficient to make a horizontal layer of water 1 inch thick. That is,

$$a(h_0 - h) = 1 \text{ inch}$$

Therefore $r_1 - r_0$, or the thickness of the captured shell, is just one-quarter of an inch, on the assumption that all the captured water turns to ice.

However, as implied above, this assumption is not allowable. If the undercooling were, on the average, even as much as 10°C. , the latent heat of fusion would prevent all but one-eighth of the water from freezing. Hence, under even these most favorable circumstances the thickness of the added shell could not be more than roughly one-thirtieth of an inch. Evidently, therefore, hailstones are not produced in this way, and we are, so far as we now can see, forced to assume uprushes of hurricane velocity for the production of very large hailstones. And that violent uprushes can and do occur in the atmosphere we know also from the remarkable feats of the tornado in lifting and carrying to considerable distances objects far more difficult to support than the largest authentic hailstones.

NOTE ON PILOTS' OBSERVATIONS OF AIR CURRENTS IN AND NEAR THUNDERSTORMS

By PAUL A. MILLER, Assistant Observer

[Moline Airport, Ill.]

About 10 o'clock on the evening of September 10, 1928, an air-mail pilot took off from Moline Airport for Kansas City. Weather conditions were very much unsettled and thunderstorms were indicated over the route he was to follow. He found, however, that there was a ceiling of about 1,000 feet, fairly good visibility and very little rain, and he experienced no trouble until he was about 15 miles beyond Fairfield, Iowa. There he found that he was nearing a thunderstorm of considerable dimensions and decided to circumvent it, if possible. The storm was moving from the southwest and he elected to run along the northeastern edge, or forefront, of it, rather than to go so far out of his way by skirting the northern edge.

After following the new course for about 5 miles, he decided to start using gasoline from the other wing tank, and so leaned down in the cockpit to turn it on. While in that position the ship was suddenly thrown almost entirely over on its back and the altimeter showed 3,500 feet within about 20 seconds, according to the pilot's estimation. After righting the ship, the pilot returned to Moline Airport, judging that the storm he was near was of particular violence aloft and it would be foolhardy to continue. He stated that, since it was very dark, he could not tell whether the high altimeter reading was due to being lifted upward very rapidly or to suddenly lowered pressure of the atmosphere.

The turning over of the plane can be accounted for, as it is well known that there are rapidly ascending and descending currents in a thunderstorm. It is also known that the barometric pressure decreases sharply in the forefront of a thunderstorm and then increases rapidly as the storm passes over a given point, but if this sudden change of 2,500 feet (he was flying at about 1,000 feet) shown by the altimeter was due to a sharp lowering of pressure, the decrease would amount to not less than 65 millimeters, which is manifestly rather improbable, ex-

cept in the presence of tornadic conditions. Such conditions were very probable at that time when the distribution of several of the meteorological elements are taken into consideration. The 7 a. m. weather map for September 10, 1928, shows a long trough of low pressure stretching northeastward across the Plains States and that thunderstorms had already occurred over the western portions of this area. There is also a sharp variation of temperature shown from high to low from east to west. These evidences, combined with the pilot's account that it occurred in the forefront of a thunderstorm, with no rain occurring before, seem to point to the probability of the presence of tornadic conditions.

On the other hand, if the altimeter change was due to an uprising current of air, the velocity of the current would have been approximately 38 meters per second; this seems rather high, although it corresponds very well with statements made by various pilots concerning the velocity of these currents and their effects upon an airplane.

Pilots who have been asked concerning experiences along this line are generally of the opinion that a violent uprising current of air in the front of the storm tossed the plane about and also lifted it very rapidly. Several stated that they have flown directly through thunderstorms and at the front of the storm have been struck by squalls which were made up of descending currents so violent that their utmost efforts were required to keep the ship from crashing, and after passing the front were lifted by the ascending currents into the clouds and could hardly get the plane down, even by pointing downward with the engine on.

The foregoing seems to indicate that in some thunderstorms the vertical air currents are much more violent than is generally supposed. Another inference would be that tornadic conditions may form aloft, of which no indication is perceived at the surface.

FIVE YEARS OF OCEAN MAPPING AND ITS FORECAST VALUE

By L. E. BLOCHMAN

[Berkeley, Calif.]

INTRODUCTION

Long-range, or seasonal, forecasting has so far been only cursorily investigated, particularly on the Pacific coast. Both short-range and long-range forecasting have been immensely assisted by ocean charting from daily radioed weather reports from ships. The main application of this service, however, is to daily or short-range forecasting; long-range forecasting is still in a tentative state for lack of sufficient data.

The ocean mapping system was not established without considerable difficulty. Credit is due to the San Francisco Weather Bureau service for its persistence in obtaining a sufficient number of ship reports to cover the desired ocean area. This extends from Honolulu to the westerly Aleutian Islands, and from this approximate westerly line to the Pacific coast of Canada and the United States on the east. The land stations of Guam, Manila, Hong Kong, St. Pauls Island in Bering Sea also report to the bureau.

As a layman I am studying prevalent seasonal conditions, especially the ocean movements of HIGHS and LOWS,

with their concomitant rains; the result of these studies is but partially embodied in this paper. In this article I also briefly discuss the recent ocean-mapped seasons, especially the very dry season of 1923-24 and the more than average rainy one of 1926-27, and some casual weather conditions of two other seasons.

THE SEMIPERMANENT LOWS AND HIGHS

In scanning our ocean and land maps for any series of years we find two dominant centers of pressure, the so-called semipermanent Aleutian Low and the semipermanent HIGH which lies off the California coast about 15° to the west. The center of the Aleutian Low is immediately south of the islands of the same name, but its center may vary for a thousand miles east or west.¹ The center of the semipermanent HIGH, above referred to,

¹ This apparent variation is explained by the fact that the so-called Aleutian cyclone owes its semipermanent character to the giving off of secondary depressions on its eastern front and receiving accessions from the west every few days. As a result the center of the cyclone seems to be stationary for a few days and then suddenly to change its position 500 to 1,000 miles to the westward.—Editor.

is not so definitely located as to latitude, ranging often between 30° and 40° . Sometimes the HIGH in winter stretches across easterly by northeasterly to the plateau between the Sierras and the Rockies. When there is a persistent dry spell in winter a plateau HIGH may exist at the same time.

This semipermanent HIGH, known as the California or the Hawaiian HIGH, dominates our coast. It is a little farther north in summer than in winter and much more permanent in summer and in very dry winter seasons than in rainier seasons. Its major axis is subject to change in summer or in the dry spells of any winter. When temporarily displaced it has an inherent tendency to return to its more or less permanent position lying east and west approximately between longitude 130° and 150° and latitude 2° 30° and 40° .

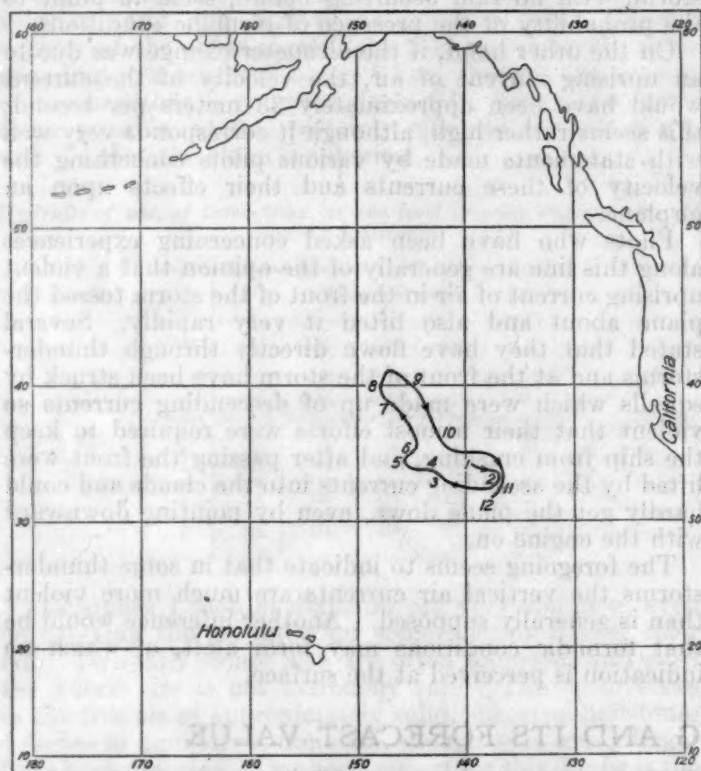


FIG. 1.—Seasonal meander of North Pacific anticyclone. The numerals 1-12 stand for the months January-December, inclusive

It is a part of the high-pressure belt which encircles the globe about north latitude 35° . Over the two oceans it is at its highest pressure west of their respective continents. The effect of this pressure distribution is to cause a marked shortage of rainfall along its southern side, as manifest in the Sahara and other deserts.

On the Japanese coast and on the Atlantic side of the United States the belt of high pressure is more or less broken up by cyclonic storms and is not therefore continuous at all times. Off the California coast this semipermanent high pressure in very dry winters seems almost as intense and persistent as in summer seasons.³

According to my observations when the summer HIGHS of September continue into October and still further into November, with concomitant plateau HIGHS, we have the

probability of a below-average rainy season. The higher the pressure as the rainy season moves on to the latter half of November and into December, the greater the probability of a dry season and not of a mere dry spell. When there is more or less mobility of pressure, i. e., occasional fluctuations to lower pressure, we may construe conditions as a later opening winter season.

With land maps only to forecast from this is a very uncertain problem because some of the conditions are unknown. It can be readily seen that ocean mapping helps immensely by giving us the lacking data. I shall endeavor to illustrate this as I proceed. There are still elements of uncertainty in long-range forecasting that only further investigations will minimize. Ocean mapping and particularly the resultant effect on our scientific theories are still in their infancy.

COMPARISON OF SEASONS

There are marked contrasts in even these last five seasons and we shall first compare two of them of opposite trend, the dry season of 1923-24,⁴ and the above average rainy season of 1926-27.⁵ In looking at the ocean weather maps for October and November, 1923, they seemed to be a continuation of the average summer HIGH, and the rains were very light, mere tapering rains from the north. But in October, 1926, several cyclonic or low-pressure areas moved south to almost latitude 30° , the southern limit of the summer HIGH and so displaced it completely. It did not yet rain appreciably in the State, the low center moving too far to the northeast as it passed inland, but it was a true forecast for rains in the following month. On November 17, 1926, the weather map showed a deep low of 29.40 inches opposite Point Conception with its center along the one-hundredth and forty-fifth meridian of longitude. But over the plateau the land map showed the excessive high pressure of 30.50 inches, due to some cold land conditions. Certainly no one, a short or a long-range forecaster, could have predicted any rains from the land map, but the ocean map justified a forecast of a very heavy rain; indeed, 6 inches fell at San Francisco, and 7 at San Luis Obispo (near Point Conception) within the following 10 days. These were excessive rains for November.⁶

The interior always has higher pressure in winter than in summer, the opposite of normal ocean conditions. The only difference observed as regards seasons is that the average pressure is higher and semipermanent in drier seasons, but in normal to wet seasons the higher and lower pressures fluctuate and alternate quite frequently.

The problem of long-range forecasting even from ocean charts is not so simple in ordinary seasons as in extreme ones. For instance, high oceanic pressure in October and November and even in December may be due in part to a later opening season, a belated summer condition, or to some other cause. The season of 1925-26 had very light rains until January; in fact, in the bay region December was much drier than November. In forecasting at the time I observed that this would not be a dry season, as Los Angeles and southern points had

⁴ Typical weather chart of dry season 1923-24, February 26, 1924. Deep low, 28.1 inches centered over Bering Sea and the west coast of Alaska. North Pacific anticyclone in normal position. Pressure over interior of continent unknown.

⁵ Typical weather chart for wet season of 1926-27, November 17, 1926. Circular low centered in West longitude 145° , North latitude 35° . Pressure high over Bering Sea and the interior of continent west of one hundred and tenth meridian—a typical pressure distribution for rains in southern California.

⁶ Typical weather chart, October 13 and 22, 1926, for heavy rains in November. Both show a deep depression in the neighborhood of Dutch Harbor with the outer limit extending southeast nearly to California coast. North Pacific anticyclone absent and pressure over continent not unusually high.

³ The marine division of the Weather Bureau made for the editor some time ago a drawings showing the average annual migration of the North Pacific semipermanent anticyclone. The drawing is produced as Figure 1 of this article.—Editor.
⁴ Cf. A. J. Henry in the Winter Anticyclone of the Great Basin, this Rev. 56: pp. 125-128.

received about three times the rainfall of the bay region. Lows had moved directly south which, like October, 1926, indicated favorable future rains. Copious January, February, and April rains brought the season up to a full normal one. Of belated opening rainy seasons we may incidentally refer to 1910-11, when only $2\frac{1}{4}$ inches of rain fell in Sacramento from September through to the end of December. In January following torrential rains came to the Sacramento Valley causing serious floods; Sacramento city had $12\frac{3}{4}$ inches, Nevada City (the same valley at the 2,500-foot elevation) had 36 inches. Had we had ocean mapping at that time, undoubtedly pressure movements in December would have indicated as it did in October, 1926, future heavy rains.

The season of 1924-25 of this ocean-mapped group shows a dry condition in the south, but full average from Salinas-Fresno northward. There are several such seasons of dry conditions in the south and normal rainfall northward. The weather map for December 30, 1924 (a dry period for southern California), shows the HIGH off the California coast with deep Low northward, over the Gulf of Alaska. But the subsequent Lows moved much farther south than in the previous dry season, and the HIGHS were not so persistent.

LOW-PRESSURE MOVEMENTS

The main low-pressure or cyclonic movement, known as the Aleutian Low, has been carefully and continuously studied and does not need any attention in this discussion. There are, however two other low-pressure movements related to the northern low-pressure system, the Hawaiian Low and the intermountain Low, or the so-called Alberta or Alberta-Plateau Low.

ALBERTA LOWS⁷

The Alberta Low has been really misnamed; it should have been called the intermountain Low. It is a Low that has moved inland along the southern Canadian line and become deflected southerly about the Province of Alberta and often before it has reached that Province. It is a cyclonic formation between two HIGHS, deflected as it encounters the easterly HIGH. In moving south toward southern Nevada and southeastern California it comes under the influence of the Pacific Ocean and its cyclonic life is revived, and precipitation follows for central and southern California, often quite heavy.

In the dry season of 1923-24 the persistent HIGH of this coast seemed as immovable as in summer. There was no probability in spring of any Low being deflected down the California coast with such an anticyclonic condition. But in three different periods in March this Alberta cyclonic movement gave the parched south above-

average rains for the month: San Diego, $2\frac{1}{2}$ inches; Los Angeles and Santa Barbara, $3\frac{1}{2}$ inches; and San Bernardino, $4\frac{1}{2}$ inches. April also had two similar rains, though lighter in amount. Los Angeles received about $1\frac{1}{2}$ inches, San Bernardino and Redlands a full $2\frac{1}{2}$ inches, while its influence, barely felt around the bay, gave San Francisco only 0.30 inch.

We give so much attention to this type of Low because we have never seen any reference paid to this particular source of rain for southern California. It is particularly a factor to be reckoned with in rains from March on. The applicability is shown in the following forecasts made in April, 1927, and this last April. About the middle of April, 1927, I forecast in a local paper (*The Berkeley Gazette*) that the rainy season was over, due to the tapering off of the northerly coast rains and particularly to the persistent oceanic high pressure. This was a correct forecast. About the same time this year under the same conditions I was correct only as far as the upper coast rains were concerned. An unexpected Alberta Low developed during the second week of May which gave southern points from Bakersfield south $\frac{1}{2}$ to $1\frac{3}{4}$ inches of rain, tapering off in the bay district to 0.30 inch.

THE HAWAIIAN LOW⁸

The Hawaiian Low is so called because first observed in the vicinity of these islands. It most likely is a southerly deflection of the Japanese-Alaskan low-pressure system before it reaches its usual center. Sometimes rainstorms are light, sometimes very heavy, from this source; they are warmer in temperature than the Alaskan Low because traversing a warmer belt.

Whenever an Aleutian Low moves south and a Hawaiian Low exists west of the California coast at the time, they apparently intensify the precipitational effect of each other. Such a coincidence was in evidence in February, 1927, which accounted for some tremendous rains in southern California in a short period of time. It can be traced in the weather maps of February 12 and 13.

On March 22 and 23 of this year it was raining in the Sacramento Valley and snowing in the mountains. On the 23d and 24th a Hawaiian Low moved in and augmented the precipitation and the warmer Hawaiian Low apparently melted the mountain snows causing heavy floods in the valley.

This brief and rambling discussion about a few recent seasons and about high and low oceanic pressures is only a partial proof of the value of ocean mapping for long-range forecasts. For short-range it is too self-evidently necessary to need any comment.

My accumulated data of years on various climatic factors bearing on long-range forecasting would have been of more value if we had had concomitant ocean maps previous to 1923.

⁷ The Weather Bureau classification of lows, as has been frequently stated, is based solely upon the place where the Low is first charted on the daily weather maps. It is held that Alberta lows are of Pacific origin, but the evidence as to the precise path followed previous to their appearance in Alberta is not yet conclusive.—Editor.

⁸ Undoubtedly the author has in mind a cyclonic depression that occasionally is found as far south as Honolulu. Meteorologists do not recognize a distinctive Low that could be called the "Hawaiian" Low.—Editor.

AEROLOGICAL ACTIVITIES AT THE NAVAL AIR STATION, SAN DIEGO, CALIF.: HISTORICAL SKETCH

W. G. LINDEMAN

Aerographer, Second Class, U. S. Navy

[San Diego, Calif.]

The aerological observatory at the naval air station, San Diego, Calif., has reached its present development mainly under two objectives: First, the dissemination of weather information to the various aviation units operating at the air station; second, the making of an aerological survey by means of pilot-balloon soundings, the collection of data of temperature and humidity of the upper air in that vicinity with an aerograph by the aid of an airplane, and the furnishing of these data to the various aviation units operating at the air station.

From November 1917, which was the beginning of naval aviation at North Island, to June, 1921, little can be said about the aerological activities, due to the following reasons taken from a report of the aerographic department for the fiscal year ending June 30, 1921:

On July 1, 1920, the aerographic department of this station was for the first time since the fire, which occurred in September, 1919, fairly well equipped with aerographic instruments.

Prior to May, 1920, this office was greatly handicapped by the lack of trained personnel to carry on the work. In May, an officer who was a trained meteorologist, was ordered to this station for duty. Upon his arrival he found everything in more or less chaotic state due to the fire, which has practically destroyed all the aerographic instruments.

The main difficulty in carrying on the aerographic work has been due to the lack of trained personnel. From the time that the aerological office was established to within the last five years, the personnel included a commissioned officer in charge, while the work was carried on by enlisted personnel, which usually consisted of an assistant who has previous training in the aerological school at Pensacola, Fla., and one or two untrained enlisted men taken at random from any other branch of the Naval Air Service regardless of qualification.

The present aerographer's rating was established in December, 1923, and during 1924 the aerographers school was inaugurated at Washington, D. C., under the direct supervision of Lieutenant Reichelderfer who also has supervision of the aerological branch of the United States Navy, and much credit is due him for its development.

Requirements for entrance are two completed years in high school, or high-school credits in physics, geometry, algebra, and physical geography. Sixteen weeks are required to finish the course of instructions, which embraces physics, mathematics, meteorology, typing, and practical work. Upon completion the graduates are detailed to the various aerological offices ashore and afloat.

In the aerological branch of the Navy there are four ratings; third class, second class, first class, and chief aerographer. Upon completion of the prescribed curriculum at the school, the student is qualified to take the examination for the third-class rating of aerographer. For advancement to the higher ratings, one year's service is required in the next lower rating before becoming eligible for examination for the next higher.

Pilot-balloon soundings have been made by the single theodolite method since July, 1920. Of course, morning soundings are lacking in continuity, due to low clouds or fog; to the fact that none are made on holidays and Sundays; and to the lack of balloons or gas. But we have a

much better and more complete record of the afternoon soundings.

Beginning with the summaries in 1924 both morning and afternoon soundings show a very marked improvement in continuity and elevations reached.

The aerograph flights began in 1923, but prior to 1924 the record is sporadic for such reasons as hazardous weather conditions, lack of aeroplanes, and the securing of operations at the station.

LOCATION OF OFFICE AND ITS EQUIPMENT

Our observatory is located on the three upper floors of the tower of the administration building, where its equipment has been permanently installed since 1922.

The instrument shelter and two theodolites are located on the top of the tower, 130 feet above the ground. It is necessary to have two theodolites for use because the balloon is sometimes obscured by the mast on the top of the tower on which the wind vane for the anemobiograph and the 3-cup anemometer is mounted.

We are justly proud of our equipment, as we are fully supplied with the instruments necessary for the recording of weather conditions and aerological survey work.

One apparatus of great importance that is used for recording wind direction and velocity simultaneously, and not usually found in United States Weather Bureau offices, is the anemobiograph made by Negretti and Zambra of London. This instrument is designed upon the Dines model, and writes directly the wind direction and velocity and in this manner indicates its gustiness.

The sunshine recorder is not the type adopted by the Weather Bureau, but is designed upon the Campbell-Stokes principle. It consists essentially of two parts: A glass sphere which brings the sun's rays to a focus, and a metal bowl carrying cards to form a belt, approximately spherical, on which the sun burns a record. On this card are vertical-line graduations for determining the hours that the sunshine occurred.

Standard instruments and equipment are used for obtaining aerographic and pilot-balloon sounding data, except that the aerograph is taken aloft by aeroplane instead of kite and the Friez type of instrument is used.

The pilot-balloon plotting board is so constructed that by using a celluloid disk with its outer edge graduated to 360°, and then plotting the horizontal distance and the azimuth angle on this celluloid disk, the wind direction and velocity may easily and readily be obtained for each minute.

Due to the fact that the tower is visible from all points in the harbor, and to the south at sea, on January 1, 1925, the office was designated a storm-warning display station of the Weather Bureau.

PERSONNEL

At present there are three aerographers assigned to our office for duty: Chief aerographer, A. A. Stotts; aerographer, second class, W. G. Lindeman; and aerographer, third class, R. P. Darr.

While virtually under the direct supervision of Lieut. W. K. Berner, the work is carried on by the aerographers.

In addition to the office routine, military duties must be performed according to regulations.

OBSERVATIONAL

Two copies of the aerological observations are entered concurrently each day in the forms perscribed. Originals are invariably forwarded to the Bureau of Aeronautics, aerological section, and one copy is filed in our office.

The assembled form contains data of surface observations, pilot balloon observations, aerograph soundings, copies of instrument record traces and a summary of the surface readings for the month.

These latter are made three times a day; at 8 a. m., 12 noon, and 4 p. m., one hundred and twentieth, meridian time. In addition to the regular observations of weather conditions, visibility, conditions of landing area and the number of hours of favorable flying weather are recorded. Visibility is recorded according to the standard scale of 0 to 9, and favorable flying weather is defined as weather in which the wind velocity is not over twenty miles per hour, the clouds, if any, are not below 4,000 feet, the visibility is not less than scale 4 (2.5 miles), there is no precipitation, and the temperatures are not below zero, Fahrenheit.

From the 1st of June of this year, we are recording water temperatures in San Diego Bay daily at 8 a. m., 12 noon, and 4 p. m., taking the readings from the air station catapult dock at a depth of approximately 20 feet. Observations include the following: Psychrometric data; temperature of surface water; temperature of water at bottom; tide periods, that is, high or low tide.

One of the two major aerological observations are pilot-balloon soundings, which are made by single theodolite methods at 7 a. m. and 1 p. m., regardless of weather conditions or height of clouds, with the exception that the 7 a. m. sounding is not made on Sundays and holidays. Special readings are taken at any time upon request from the various aviation units operating at North Island. Soundings that are taken at night are usually made to obtain upper air data for night flying. The only change in the method of making these is that a tissue paper lantern with a lighted candle is fastened on the balloon by a piece of tape. To compensate for this extra weight, the lantern and candle are weighed together to determine the amount of hydrogen to use in inflating the balloon so as to give it the rate of ascent that is being used. Then when the balloon is released the light from this lantern is observed through the theodolite.

A system for increasing the speed of the computations of the soundings was put into practice during April of this year by installing a telephone from the point of observation to the plotting room two stories below. Two men are required to make a sounding by this system. The observer at the theodolite is equipped with a headset and mouthpiece and as he reads the angles of elevation and azimuth at the 1 minute intervals, his assistant at the receiving end records these data and computes the horizontal distances by slide rule. He then plots these data on the board, and obtains the wind direction and velocity. Consequently at the end of the sounding the entire report is complete, thus saving the additional time required of plotting after the sounding has been made.

In addition to furnishing a report of the pilot-balloon soundings to the various aviation units, a coded message of the 7 a. m. and 1 p. m. soundings is sent to the Weather Bureau office at San Francisco, via naval radio, in return for which we receive the daily weather forecast for Southern California.

The other major aerological observation is the aerographical flight. Our office is one of the few having equip-

ment for the making of observations by aeroplane, and a distinct advance was made recently when we adopted the adiabatic graph for charting.

FORECASTING

Previous to the change in the methods of receiving their reports, the weather data for the drawing of the synoptic chart and making of the forecast was obtained from the Weather Bureau office at San Diego. Now the communication office at the Naval Air Station copies the 6:15 a. m. weather report broadcasted from San Francisco by naval radio. This bulletin contains current weather observations from stations in the United States, Canada, Alaska and also ship reports. The 7:30 a. m. and 7:30 p. m. weather bulletins which contain weather reports, information, forecasts, and storm warnings for the benefit of marine and aviation interests, also including aerological data from various western stations, are also copied.

From these reports the a. m. weather map is completed at 8:15, three copies of which are distributed for reference to various places in the administration building. One evening map is drawn for the office files from the 7:30 p. m. broadcast.

Each morning a bulletin is prepared consisting of the latest weather reports from important cities and air bases, giving in detail the time of observation, conditions of sky, state of weather, lowest clouds and height in feet, visibility, conditions of landing field, winds—direction and velocity at surface and at 5,000 feet—and the outlook for flying. The detailed aviation weather forecast for this locality covers the periods of "to-day," "to-night," and "to-morrow," giving in detail expected cloud ceiling, visibility, etc., of value for flight operations.

In our forecast verification absolute exactness is unnecessary because the purpose of the forecast is to meet the practical needs of naval aviation, and there are certain limits within which variations in weather conditions are of little significance. Consequently tolerances, based upon the needs of aviation, are allowed in the verifications.

As the Army at Rockwell field occupies the southern section of the island and the naval air station, fleet air squadrons, and the Marine Corps aviation group are combined on the northern section, all operations are consequently close together. Forecasts are issued to the last three groups, but we are not allowed, by orders, to issue them to civilian pilots or commercial aviation organizations.

Copies of the weather bulletin are distributed to the commanding officer, executive officer, officer of the day, Naval Air Station operations office, fleet air officer of the day, land-plane squadrons, sea-plane squadrons, and Marine Corps aviation group office.

Special forecasts are issued for cross-country flying and forecasts for this vicinity are also sent by radio to various ships of the Navy along the coast when requested.

FUTURE DEVELOPMENTS

Steps have been taken for future expansion by the installation of equipment at three places in San Diego County, for the purpose of locating the best prospective sites for an airship base.

Each equipment consists of instruments for recording wind velocity, gusts, and direction, air temperature, humidity, sun temperature, which by comparison with air temperature in the thermo-screen, gives the amount of sunshine. Statistics of these elements are required in order to determine matters of hangar orientation and general suitability for the operation of airships.

With an increasing trained personnel it is hoped that a definite program of research and correlation can be carried

out, which will ultimately give us a better conception of the processes connected with the formation and dissipation of fog—aviations greatest hazard. With an increasing number of aerological observations, local problems connected with the upper air such as temperature inversions, turbulences, eddies, unexplained wind directions, etc., can be charted and given serious consideration.

If the results of our studies have done nothing else, they have proved conclusively that death pockets, holes in the air, death spots, etc., are all phantasies of publicity seekers in the super-sensational Sunday supplements.

For a bureau in its infancy we have made rapid strides and there is little doubt in my mind that the solution of many of the problems of meteorology will be found in the records which we are accumulating.

A 12-YEAR RECORD OF HOURLY TEMPERATURES AT RICHMOND, VA.

By H. A. FRISE

[Local Weather Bureau Office, Richmond, Va.]

In presenting the 12-year record of hourly temperatures 1911-1922, the results are not offered as representing mean temperatures that are normal to this locality, but rather to show the magnitude of the difference between mean temperatures derived from but two points on the daily curve, the maximum and the minimum, and those derived from the mean of the 24 hours. For practical purposes the mean of the extremes is quite close to the true mean for a good part of the year, though for the warm months there is a considerable departure. There is no doubt that for all lengths of record the mean of the daily extremes departs most from the 24-hour mean. (See fig. 1.)

Whether the departure, say for July, is as great for a 40-year period as for one of but 10 years has not been determined because of the large amount of labor involved, but it is not believed that a long record would alter the comparative result of a 12-year record materially.

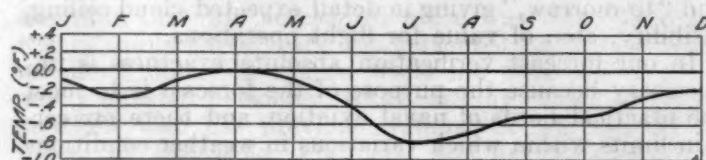


FIG. 1

Table 1 shows the winter, summer, and annual mean temperature as derived from means of the 24 hours for the years above named and figure 1 shows the variation of the means derived from the daily extremes from the means of the 24 hours.

In Table 2 I have given the summer and winter mean range, as computed from (a) the readings of self-registering maximum and minimum thermometers, and (b) from corrected readings of the thermograph for the warmest and the coldest hours of the day, respectively. For winter the hours of 7 a. m. and 3 p. m. have been chosen and for summer 5 a. m. and 3 p. m.

This table shows that the range computed from self-registering thermometers is for winter 17.9° and for summer 19.6°. The mean range between the warmest and the coldest hours, respectively, is for winter but 12.6° or 5.3° less than from self-registering thermometers as might be expected. In summer the difference is less, being but 2.4°. This is explained by the fact that the winter mean for January, for example, rises but 0.2° farther above the mean of the 24 hours than the minimum sinks below it, whereas in July the maximum, 87.1°, rises 1.4° farther above than the mean minimum falls below it. This excess in the maximum temperature explains the larger deviation of the July mean of the daily extremes from the mean of the 24 hours. It would be interesting to see whether this excess in the maximum temperature in summer holds for other places than Richmond. Strictly speaking, the mean of the 3 p. m. temperatures should not be the same as that of the daily maximum thermometer.

TABLE 2.—Comparison of monthly range in temperature as obtained (a) from readings of maximum and minimum thermometers and (b) from readings of thermograph (corrected) at hours of highest and lowest temperatures, respectively

FROM MAXIMUM AND MINIMUM THERMOMETERS					
	Maximum	Minimum	Range		
December.....	48.0	31.0	17.0	June.....	83.4
January.....	47.3	29.3	18.0	July.....	87.1
February.....	48.7	29.9	18.8	August.....	85.8
Mean.....	48.0	30.1	17.9	Mean.....	85.4

FROM HOURLY MEANS OF WARMEST AND COLDEST HOUR					
	Maximum 3p	Minimum 7a	Range		
December.....	46.4	34.2	12.2	June.....	82.0
January.....	44.8	33.1	11.7	July.....	85.5
February.....	46.6	32.6	14.0	August.....	84.4
Mean.....	45.9	33.3	12.6	Mean.....	84.0

TABLE 1.—Mean hourly temperatures, the year, and for winter and summer at Richmond, Va., 1911-1922

YEAR																										
A. M.												P. M.													Mean	Mean of extremes same period
1	2	3	4	5	6	7	8	9	10	11	Noon	1	2	3	4	5	6	7	8	9	10	11	Mid-night			
53.0	52.2	51.5	50.9	50.3	50.2	51.0	52.9	56.2	59.1	61.5	63.4	64.9	65.8	66.1	65.7	64.4	62.5	60.4	58.6	56.7	55.1	54.6	53.7	57.5	57.9	
WINTER																										
36.0	35.5	34.9	34.4	33.8	33.6	33.3	33.7	35.5	38.1	40.6	42.7	44.4	45.4	45.9	45.6	44.4	42.8	41.3	40.2	38.9	37.9	37.3	36.6	38.9	39.0	
SUMMER																										
60.4	68.7	68.0	67.4	66.8	67.1	69.0	71.9	75.5	78.3	80.4	81.9	83.2	83.9	84.0	83.3	82.1	80.4	77.9	75.6	73.5	71.9	71.1	70.1	75.1	75.7	

NOTES, ABSTRACTS, AND REVIEWS

THE INTERNATIONAL GEOGRAPHICAL CONGRESS AT LONDON, JULY, 1928

By HENRY J. COX

[Weather Bureau Office, Chicago, Sept. 17, 1928]

The preliminary meetings of the congress were held in London, where most of the members arrived on July 13.

On the afternoon of Saturday, July 14, a reception was tendered the members by the president and council of the Royal Geographical Society at the house of the society in Kensington Gore.

On the afternoon of Sunday, July 15, there was a reception at the Science Museum in South Kensington for the members.

On the evening of Monday, 16, the lord mayor of London and the corporation of the city gave a reception and conversazione at the Guildhall. Dancing followed the reception; and the Prince of Wales was present and took part on the ceremonies.

On Tuesday, July 17, the congress moved to Cambridge, where the general and sectional meetings took place in the university buildings. The meeting of the general assembly of the union was held at 8:30 p. m.

Meetings of the various sections were scheduled thereafter, with frequent receptions and excursions until the close of the congress on Wednesday, July 25.

The most important special functions at Cambridge were a dinner given by Sir Austen Chamberlain, Secretary of State for Foreign Affairs, to the delegates at Trinity College the evening of Tuesday, July 24, and the reception to all the members that followed at St. John's College later in the evening; and also the award of the degree of LL. D. to Gen. Nicola Vacchelli, of Italy, retiring president of the union; Col. Sir Charles Close, president of the Royal Geographical Society of London; and Prof. Emmanuel de Martonne, of France, by the University of Cambridge, the vice-chancellor officiating.

There were in all about 30 Americans present at the congress, of which seven were official delegates, including myself. Moreover, about 40 countries were represented, but only about 20 of these were qualified to have delegates because of their adherence to the International Geographical Union.

In all, there were about 500 members listed as attending from various parts of the world.

Germany, Austria, and Hungary had not joined the union and therefore were not represented at the congress.

Papers were read by the American delegates as follows: Col. E. Lester Jones, Chief of the Coast and Geodetic Survey, "Geographical Importance of Coastal Surveys" and "The National Geographic Society."

Dr. Wallace W. Atwood, president of Clark University, "The Physiography of the San Juan Mountains" and "A Graduate School of Geography."

Prof. D. W. Johnson, president of the Association of American Geographers and professor at Columbia University, "The Problem of Sea-Level Changes in Eastern North America."

There were also two papers read by Prof. E. L. Stephenson, secretary of the Hispanic Society of New York City,

although not an official delegate, one of which was "Early Spanish Mapping in the New World."

At the final meeting of the congress certain resolutions were offered and passed unanimously as follows:

1. For reappointment of the commission for the study of Pliocene and Pleistocene terraces.

2a. That in the countries in which the official services have undertaken surveys in regions where there are desert or sandy areas, surveys should be made, if possible, on a scale big enough to determine the characteristic features and to obtain, if possible, a close representation of the topographical features.

b. That conventional signs, allowing of incorrect interpretations being given morphologically and climatologically, should be eliminated in sufficiently known regions.

3. For the appointment of a commission for the study of "The Flora and Fauna Population of Mountains."

4. That the union encourage research and preventive measures against calamities;

Is gratified with the important cooperation which is therefore reserved for the historical and geographical sciences;

Observes that several geographical societies have already initiated the preparatory work for drawing up an historic-geographical chart of calamities;

Invites students of history and geography, and geographical societies throughout the world, to accept the responsibility of cooperation assigned to them in connection with the International Assistance Union, and to contribute with all their own organizations—

a. To the preparation of the above-mentioned historico-geographical chart;

b. To the division of continents into geographical zones of calamities;

c. To the study of the determinism of nature's scourges;

d. And generally to supply correct scientific data for the technical and preventive preparation of the work of saving populations overtaken by great natural disasters.

5. In the study of the geographical environment concerning the earliest history of man, the union proposes a resolution for the establishment of an international commission for the preparation of paleogeographical maps of the plio-Pleistocene ages.

6. A resolution is proposed that it would be of great interest, from an historical and geographical point of view, if an edition of the necessary sheets of the international 1/M map were published, showing by an overprint the extent of the Roman Empire, with its main communications and other features of its organization, at the time of its greatest expansion; and that, in order to give effect to this purpose, a commission should be appointed of representatives of the countries interested. By this means it is hoped that it may be possible to publish some sheets of this edition before the next Congress.

7. That there should be established in each European country an inventory of old maps preserved in public libraries or in private collections, and relating to its territory;

That a committee of experts should be appointed to make a selection of these documents and publish a photographic reproduction, according to the sample furnished by the *Monumenta Cartographica Italica*.

8. The Commission of the Rural Habitat proposes the resolution to establish a map of the distribution of the different types of habitat in the greatest possible number of countries. To this end, the commission has chosen some collaborators who will undertake to draw up, comment and apply the map of the types of habitat in their respective countries, according to the map of Belgium published by Dr. M. A. Lefevre.

Gen. Robert Bourgeois, of France, was elected president of the International Geographical Union at the final meeting, and Dr. Isaiah Bowman, director of the American Geographical Society of New York City, was chosen one of the vice presidents. The latter also served as chairman of the American delegation during the proceedings.

The congress, upon adjournment, decided to meet in Paris in 1931.

FURTHER STUDIES IN TERRESTRIAL RADIATION¹

By G. C. SIMPSON, C. B. F. R. S., F. R. Met. Soc.

The results obtained in this paper are so different from those obtained in the previous paper, *Some Studies in Terrestrial Radiation*, that it is necessary to review the whole position, to find the causes of the differences and to estimate their significance. The chief difference in the procedure adopted in the two papers is that in the former we assumed that water vapor absorbs like a gray body; that is, the absorption is the same for all wave-lengths greater than 2μ ; while in this paper each wave-length has been assigned its appropriate absorption.

The former method may almost be dignified by the adjective classical. It was used in all the papers which have laid the foundation of our ideas on terrestrial radiation, among other by Humphreys,² Gold (in part),³ Emden,⁴ Hergesell,⁵ and Mügge.⁶ While most of the previous writers approached the problem from considerations of radiative equilibrium, Hergesell and I approached it from the point of view of the existing distribution of temperature and water vapor, and calculated the radiation which would result from these conditions without any consideration of how the temperature conditions are maintained.

Two outstanding results followed from my previous paper which are now shown to be wrong, because of the assumption that water vapor absorbs like a gray body. These are (a) the outgoing radiation originates in the layers of the atmosphere which have temperatures between 220° a and 286° a, and therefore are well within the troposphere; and (b) the stratosphere provides an insignificant amount of terrestrial radiation. The new investigation shows that with clear skies in middle latitudes the radiation is provided by the surface, the atmosphere and the stratosphere in the following proportions: From the stratosphere alone, 38 per cent; from the surface alone, 32 per cent; and from the surface atmosphere and stratosphere in different proportions, 30 per cent. The proportions are slightly different in different latitudes, while with overcast skies, the contribution from the ground is replaced by a smaller contribution from the clouds.

The new results affect previous work materially. Emden found that the stratosphere sends no radiation downwards, and of course the same result came out of my previous work. The new investigation shows that the stratosphere sends on the average a downward flux of longwave radiation of more than $.120 \text{ cal./cm.}^2/\text{min.}$, which is more than 43 per cent of the effective solar radiation. This agrees with the observations made by Angström on mountain peaks and in balloons, which revealed a downward radiation of between $.13$ and $.16 \text{ cal./cm.}^2/\text{min.}$ at heights between 4,000 and 5,000 metres, where, according to Emden,⁷ there should have been less than $.05 \text{ cal./cm.}^2/\text{min.}$

Any radiation which the stratosphere sends downwards has to be sent out again, therefore this amount has to be

added to the flux of terrestrial radiation which would be necessary to return the effective solar radiation alone. In other words, the effective solar radiation being .278, the outgoing radiation crossing the base of the stratosphere must be $>.278 + .120, i.e. >.398 \text{ cal./cm.}^2/\text{min.}$ Emden and Humphreys have derived expressions which purport to give the temperature of the stratosphere from considerations of the radiation crossing the base of the stratosphere. Both have neglected the long-wave radiation from the stratosphere which crosses its lower layers just as the terrestrial radiation crosses them, but in the opposite direction. Both have assumed grey or nearly grey radiation, so neglecting the fact that a large proportion of the terrestrial radiation is not absorbed at all by the stratosphere. In so far as both Emden and Humphreys simply equate the amount of energy absorbed to the amount emitted their methods are correct in principle; but as the numerical values they employ far from represent the facts, their results are of little value. It is little more than a coincidence that the expressions used by these investigators give even an approximate value for the temperature of the stratosphere.

The lesson to be learnt from this work is that totally misleading results follow from the assumption that water vapour absorbs like a grey body, and that even qualitative results can not be obtained on that assumption.

Many problems of atmospheric radiation have apparently been solved by the use of this assumption, and in all these cases the problems must be reexamined using the known absorption of water vapour in the various wave-lengths. At present we have no satisfactory answers to any of the following questions:

(a) Why does not the temperature in the stratosphere decrease with height?

(b) Why does the temperature of the stratosphere increase as we pass from low to high latitudes?

(c) Why is the base of the stratosphere higher over equatorial than over polar regions?

The answer to the first problem will probably involve consideration of the high temperatures, at 40 to 50 kilometres above sea level, which we now associate with the ozone layer; this was not mentioned by Emden, but was referred to by Humphreys in his first paper on this subject.

As to the two latter questions we have as yet no solution in sight; but the controlling factor will probably be found to be in the dynamics of the troposphere rather than in the thermodynamics of the stratosphere.

SUMMARY

By using the observed temperatures of the earth's surface and of the stratosphere, and observed values for the absorption of coefficients for water vapour and carbon dioxide, approximate values have been obtained for the outgoing radiation from the earth and its atmosphere, and the laws governing nocturnal radiation have been indicated. Values have been found for the horizontal transfer of heat across the circles of latitude which is necessary to obtain radiative equilibrium of the atmosphere as a whole. The consequences of changes in the intensity of solar radiation have been investigated, and the conclusions drawn that change in cloud amount would be the chief agency by which radiative equilibrium would be restored. An increase in solar radiation would result in increased

¹ In March, 1928, Dr. George C. Simpson published as number 16 of Volume II of the *Memoirs of the Royal Meteorological Society* a paper entitled "Some Studies in Terrestrial Radiation."

He now publishes as number 21 of Volume III of the same series the results of fresh investigations on the same subject under the title "Further Studies in Terrestrial Radiation."

Inasmuch as the results of the later investigations differ somewhat from those reached in the early studies, the author's review and conclusions are printed in full. Editor.

The full paper can be obtained from Edward Stanford (Ltd.), 12, 13, and 14 Long Acre W. C. 2, London, at the price of 2 shillings and 6 pence. Editor.

² Humphreys, *Astrophysical Journal*, vol. 29, p. 14, 1909.

³ Gold, London, *Proc. R. Soc.*, vol. 82 (A), p. 43, 1909.

⁴ Emden, *München Sitzber. Bayr. Akad. Wiss.*, p. 55, 1913.

⁵ Hergesell, *Lindenberg Arbeit. Preuss. Aero. Obs.*, vol. 13, Wiss. Abb.

⁶ Mügge, *Zs. Geophysik, Braunschweig*, vol. 2, p. 63, 1926.

⁷ Emden, *Loc. cit.*, p. 129.

cloud and precipitation, while a decrease in solar energy would lead to less cloud and less precipitation. The possibility of increased solar activity leading to an "ice age" is discussed.

Suzuki on fires and the weather.—The author⁸ presents in this monograph of 73 octavo pages a vast amount of detailed experimental research, all of which bear witness to the thoroughness of the study. It is quite impossible with the space at command to present a comprehensive review of the various aspects of the research. I shall therefore confine my remarks to those phases of the subject that most appeal to similar studies in this country. Here forest fires only are studied with reference to the associated weather conditions. The author's study, on the contrary, has to do with conflagrations involving buildings, whether singly or in mass, as well as forest fires.

A large part of the statistical material of the study was accumulated through the very simple expedient of burning the ordinary incense stick sold in the shops of Japan. This stick is a thin cylinder with diameter nearly 1.45 mm. and made mainly of powder of fragrant wood and partly of pine resin used as paste. When the upper end is lighted and the stick held upright it burns down steadily without flame.

If conditions remain the same it continues to burn always at a uniform rate.

The incense stick is peculiarly sensitive to moisture and absorbs it readily when exposed to the air, thus five sticks so dried that their total weight was reduced to 1.159 g. when exposed to the air became gradually heavier and after an exposure of 3 hours and 40 minutes reached a maximum weight of 1.259 g.

The effect of the wind in the burning of an incense stick was thoroughly investigated by means of a wind tunnel and cleverly devised apparatus. It was found that the burning velocity 5.3 m/min. at dead calm rises to the maximum 6.3 m/min. when the air current strength becomes 110 m/min. and then gradually decreases until the current velocity rises to 220 m/min., when suddenly the fire in the incense stick goes out.

With respect to the variation of the water content of timber the author concludes:

The weight of the timber varies in harmony with the change of relative humidity, only differing with regard to time. The time may be retarded by several hours, the actual amount of which depends on the manner of the variation of the humidity.

His conclusions with respect to other phases of the subject are summarized in the following paragraphs.—A. J. H.

SUMMARY

Burning every day several incense sticks through a year the author has found that they burn more rapidly in summer than in winter, whilst the daily variation of their burning velocity is subjected to the changing relative humidity of surrounding air. Further, using several other materials the influence of humidity on the burning together with house fires is thoroughly investigated, thus:

1. The most important factor of the problem among the numerous meteorological elements is the relative humidity.
2. The combustion of some substances is influenced, in large degree, by the variation of the water quantity within when they burn in low temperature without flame.
3. The combustion of some substances is influenced by the water quantity of air when they burn with flame and temperature is moderately high.
4. The combustion of other substances is, if temperature is enormously high, controlled by the humidity of air, but in the way contrary to the preceding; that is, they burn strongly with increasing humidity.

⁸ Seitaro Suzuki, "The fires and the weather," Journal of the Department of Agriculture, Kyushu Imperial University, vol. 2, No. 1.

5. The influence of wind on fires is not so remarkable as it is now believed.

6. The fire statistics in many cities and prefectures in Japan indicates that the outbreak of fires has the most intimate correlation with the relative humidity among many other meteorological elements.

7. The outbreak of fires undergoes a change yearly and daily. It corresponds in many respects with the seasonal and daily variations of the moisture in timber, paper, and cloth, etc., in the room.

Therefore we can conclude that the relative humidity has the great influence not only on the burning but also on the fires.

Solar coronas of 1°, 2°, and 3° in very clear sky (by Eric R. Miller).—Instead of the usual bright glare around the sun, I was surprised to see three bright rings, exhibiting the colors of the spectrum, when I looked at the sky near the sun at 11:45 a. m., August 31, 1928. These rings were so easily seen that I pointed them out to a number of persons, all of whom saw them easily. They lasted until about 3 p. m., when increasing cirrus obscured them. I measured the red circles, which were most easily seen, and found the radii to be approximately 1°, 2°, and 3°. The rings were again visible on September 2.

The sky was unusually clear. The usual measurement of sky polarization with Pickering polarimeter at 8:18 a. m., August 31, when the zenith distance of the sun was 60°, gave a percentage of 77, which is unusually high.

My surmise is that these rings are a regular solar phenomenon, visible only when glare due to cloud, haze, and dust is absent. I have never seen them before, and recall no reference to them in the literature of meteorological optics. If they have been previously described, I should appreciate having a reference to the publication.

Recorded observations of the Hess ultragamma radiation at Muottas Muraigl (2,456 m.) (by G. Hoffman and F. Lindholm).—Summary: The increase in the ionising effect of penetrating radiation by the use of compressed carbonic acid gas for filling the ionisation chamber together with an electrometric compensating arrangement enables an accuracy of 1–2% to be attained. Continuous records of penetrating radiation are carried out at Koenigsberg (at sea level) and at Muottas Muraigl (2,456 m.) in the Upper Engadine, with a lead screen for shutting out the softer rays from around. The intensity varies with the changes in barometric pressure, but in an irregular manner. No simple variation of intensity according to sidereal time exists. It will be possible to draw further conclusions only after new and extensive observations have been made. By measuring the absorption power of different protecting screens, diffusion effects are found which confirm the character of Hess radiation as ultra-γ-radiation.

METEOROLOGICAL SUMMARY FOR SOUTHERN SOUTH AMERICA, JULY, 1928

By J. BUSTOS NAVARRETE

[Observatorio del Salto, Santiago, Chile]

During July the weather was relatively dry in central Chile and but little rainy in the regions farther south. This was due to two factors: (1) Diminished intensity of atmospheric circulation over the South Pacific and (2) deviation toward the south in the mean path of the depressions, which usually reach the coast between latitudes 40° and 45°.

Depressions crossed the extreme south during the following periods: 1st–4th, 5th–7th, and 14th–15th. The first and second of these storms brought rain as far north as Concepcion; the third was of little importance and

the rainfall area reached only to Valdivia. The depression of the 7th-12th, the most important of the month, appeared in latitude 40° and recurved toward the north-west; it was accompanied by unsettled weather and rain from Chiloe to Coquimbo. The depression off Isla Mocha on the 17th caused fog in the central region and light rain in the southern region.

Periods of fine weather, cold wave, and frost accompanied the principal anticyclones charted during the

following periods: 12th-16th, 18th-22d, 23d-25th, and 27th-31st. The first three formed in the region of Chiloe and advanced toward northern Argentina, while the fourth moved from Juan Fernandez toward central Chile and Argentina. The severest cold wave occurred at the end of the month—minimum temperature -11° F. at Caracoles, in the Province of Antofagasta.

Total monthly precipitation: Santiago, 1.81 inches; Valdivia, 17.84 inches.—Translated by W. W. R.

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SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING
AUGUST, 1928

By HERBERT H. KIMBALL, Solar Radiation Investigations

For a description of instruments and exposures and an account of the method of obtaining and reducing the measurements the reader is referred to the REVIEW for January, 1924, 52:42; January, 1925, 53:29, and July, 1925, 53:318.

Table 1 shows that solar radiation intensities averaged above normal values for August at all three stations.

Table 2 shows that the total solar radiation received on a horizontal surface directly from the sun and diffusely from the sky was above the August normal at Madison and Lincoln and below the normal at Washington.

Skylight polarization measurements made at Washington on seven days give a mean of 52 per cent, with a maximum of 54 per cent on the 13th. At Madison measurements made on seven days give a mean of 67 per cent with a maximum of 77 per cent on the 31st. These are close to the corresponding average values for August at Washington and considerably above at Madison.

TABLE 1.—Solar radiation intensities during August, 1928

[Gram-calories per minute per square centimeter of normal surface]

Washington, D. C.

Date	Sun's zenith distance										Local mean solar time	
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°		Noon
	75th mer. time	Air mass										
		A. M.					P. M.					
		e.	5.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0		5.0
Aug. 2	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.	
Aug. 3	17.37				0.82	1.17					18.59	
Aug. 6	17.37				0.88						19.89	
Aug. 13	17.37				0.97	1.25					16.79	
Aug. 14	10.59				1.41		1.03				9.14	
Aug. 18	11.81	0.73	0.84	0.98	1.12	1.34	1.12	1.03			13.13	
Aug. 19	18.59				0.66						18.59	
Aug. 20	14.10	0.63	0.74	0.86	1.03						12.24	
Aug. 21	12.68	0.59	0.68	0.79	0.90						14.10	
Aug. 28	19.89				1.07						18.59	
Aug. 29	19.23	0.48	0.56	0.65	0.80	1.07					20.57	
Aug. 30	20.57		0.56	0.69	0.88	1.18					18.59	
Means		0.61	0.68	0.79	0.91	1.24 (1.12)	(1.03)					
Departures		-0.03	+0.01	+0.05	-0.01	+0.01	+0.10	+0.15				

Madison, Wis.

Aug. 10	16.20				1.07	1.42					14.10
Aug. 11	10.59				1.07	1.24					10.21
Aug. 13	11.38				1.13	1.35					12.24
Aug. 14	10.59				1.04	1.25					13.13
Aug. 18	11.38				1.15	1.36					11.38
Aug. 21	12.68				1.40	1.24					9.83
Aug. 22	9.83		0.94	1.03	1.18	1.40					9.14
Aug. 25	10.21			1.12	1.26						0.47
Aug. 30	12.24				1.43						10.21
Aug. 31	7.29			1.17	1.31	1.45					7.29
Means		(0.94)	1.11	1.15	1.37 (1.24)						
Departures		+0.10	+0.06	-0.04	+0.06	+0.17					

Lincoln, Nebr.

Aug. 1	16.79		0.80	0.92	1.09	1.34	1.08				18.59
Aug. 2	16.79		0.81	0.94	1.10						18.59
Aug. 4	14.10		0.68	0.78	0.89						14.10
Aug. 6	16.20		0.71	0.88							17.96
Aug. 7	16.20				1.37	1.13	0.94	0.82	0.70		14.10
Aug. 8	15.11		0.87	0.96	1.14	1.29	1.02				17.37
Aug. 9	17.96	0.71	0.83	0.90	1.10	1.35					15.11
Aug. 10	16.79		0.59	0.81	0.97	1.19					17.96
Aug. 13	17.37	0.53	0.64	0.79	1.00	1.28					17.96
Aug. 15	17.37				0.89	1.12					16.20
Aug. 20	16.20				1.20	1.01					17.37
Aug. 21	12.24			0.99	1.18	1.29					10.59
Aug. 23	15.65						1.01	0.87	0.78		10.21
Aug. 24	6.50				1.32	1.46	1.28	1.12	0.99	0.89	6.02
Aug. 25	8.81	0.80	0.94	1.04	1.22	1.34					10.59
Aug. 27	13.13				1.33	1.04	0.80	0.70	0.60	0.60	14.60
Aug. 29	16.79				1.21	1.12	1.04	0.96	0.84	0.84	18.59
Aug. 30	8.18		0.98	1.14	1.26	1.39	1.14	0.95	0.82	0.71	10.59
Means		0.70	0.78	0.92	1.10	1.30	1.10	0.98	0.86	0.75	
Departures		+0.04	+0.00	+0.02	+0.02	+0.00	+0.03	+0.09	+0.10	+0.05	

1 Extrapolated.

TABLE 2.—Solar and sky radiation received on a horizontal surface
[Gram-calories per square centimeter of horizontal surface]

Week beginning—	Average daily radiation						Average daily departure from normal		
	Washington	Madison	Lincoln	Chicago	New York	Twin Falls	Washington	Madison	Lincoln
1928	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
July 30	469	373	470	299	399	637	+28	-88	-55
Aug. 6	324	554	614	434	203	739	-113	+98	+108
Aug. 13	423	500	500	411	373	753	-2	+61	+13
Aug. 20	383	424	524	332	222	666	-22	-11	+28
Aug. 27	376	402	450	344	307	677	-37	-6	-5
Deficiency since first of year on Sept. 2							-800	-319	-1,766

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. C. S. Freeman, Superintendent U. S. Naval Observatory]

[Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, and Mount Wilson Observatories]

[The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column]

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longitude	Latitude	Spot	Group	
1928	H. m.	°	°	°			
Aug. 1 (Naval Observatory)	11 43	-82.0	46.4	+5.5	123		
		-30.0	98.4	+7.0		139	
		-30.0	98.4	-25.5	31		
		-24.5	103.9	-17.0		93	
		-18.5	109.9	+10.5		46	
		+7.0	135.4	+14.0		340	
		+14.0	142.4	+13.5		432	
		+17.5	145.9	-20.0		31	
		+23.5	151.9	-20.0	22		
		+38.5	166.9	+6.0	31		
		+44.5	172.9	+5.5		62	
		+79.0	207.4	+13.5	123		1,473
Aug. 2 (Naval Observatory)	12 6	-75.5	39.5	+8.5	309		
		-68.0	47.0	+5.5	108		
		-41.0	74.0	-3.5	31		
		-20.0	95.0	+6.0	22		
		-18.0	97.0	-25.5	15		
		-15.5	99.5	+7.5		164	
		-11.0	104.0	-17.5		154	
		-3.0	112.0	+10.5	31		
		+22.5	137.5	+13.5		309	
		+28.0	143.0	+13.0	370		
		+38.0	153.0	-20.0	22		
		+67.5	172.5	+5.5		93	1,618
Aug. 3 (Naval Observatory)	11 29	-62.5	39.6	+8.5	340		
		-55.0	47.1	+5.5	62		
		-29.0	73.1	-3.5		46	
		-5.5	96.6	-25.5	9		
		-1.0	101.1	+8.0		164	
		+2.0	104.1	-17.0		123	
		+10.0	112.1	+10.5	15		
		+33.0	135.1	+14.5		154	
		+40.0	142.1	-19.5		93	
		+41.0	143.1	+13.0	370		
		+70.0	172.1	+5.0		62	1,428
Aug. 4 (Naval Observatory)	11 3	-75.0	14.1	+14.5	46		
		-73.5	15.6	-14.0		62	
		-65.5	23.6	-13.5	31		
		-49.5	39.6	+8.5	247		
		-42.0	47.1	+5.5	40		
		-40.5	48.6	-11.0	6		
		-16.0	73.1	-3.5		46	
		+11.0	100.1	+8.0		164	
		+15.0	104.1	-17.0		46	
		+22.0	111.1	+10.5		18	
		+47.0	136.1	+14.0		123	
		+62.5	141.6	-18.5		62	
		+63.5	142.6	+13.0	370		1,251
Aug. 5 (Naval Observatory)	11 29	-61.5	14.1	+14.5	31		
		-60.0	15.6	-15.0		46	
		-54.0	21.6	-14.0		77	
		-36.0	39.6	+8.5	247		
		-27.5	48.1	+5.5	40		
		+27.0	102.6	+7.5		93	
		+38.5	114.1	+10.0	9		
		+62.0	137.6	+14.0		123	
		+69.5	145.1	+13.0	340		1,006

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longi- tude	Lat- itude	Spot	Group	
1928—Continued							
Aug. 6 (Naval Observa- tory).	H. m. 11 38	°	°	°			
		-46.5	15.8	-17.0		216	
		-39.5	22.8	-14.5		31	
		-22.0	40.3	+8.5	247		
		-14.5	47.8	+5.5	37		
		+32.0	94.3	-14.5		56	
		+39.5	101.8	+6.5		46	
		+50.0	112.3	+10.0		15	
		+82.0	144.3	+13.0	370		1,018
Aug. 7 (Naval Observa- tory).	12 46	-6.5	42.0	-19.0		77	
		-33.0	15.5	-18.0		216	
		-28.5	20.0	-15.5		154	
		-13.6	35.5	+10.5	9		
		-8.5	40.0	+8.5	201		
		-8.5	40.0	+12.0		31	
		0.0	48.5	+5.5	31		
		+21.0	69.5	+9.5		9	
		+65.0	113.5	+10.0	46		774
Aug. 8 (Naval Observa- tory).	11 25	-52.5	343.5	-19.0		62	
		-21.0	15.0	-18.5		216	
		-18.0	18.0	-16.0		62	
		-13.5	22.5	-15.5		185	
		-1.5	34.5	+19.5		46	
		+4.5	40.5	+8.5	154		
		+12.0	48.0	+5.5	31		
		+48.0	84.0	+31.0	3		
		+59.0	95.0	-15.0		12	
		+61.0	97.0	-13.5	15		786
Aug. 9 (Naval Observa- tory).	11 33	-87.0	295.7	+3.5	154		
		-39.5	343.2	-18.5		46	
		-8.5	14.2	-19.0		154	
		-3.5	19.2	-16.0		123	
		+1.0	23.7	-15.5	154		
		+13.0	35.7	+19.5		15	
		+18.0	40.7	+8.5	154		
		+26.5	49.2	+6.0	15		
		+63.5	86.2	+30.0		6	
		+69.0	91.7	-15.5	15		
Aug. 10 (Naval Observa- tory).	11 35	+74.0	96.7	-13.5	25		861
		-72.5	297.0	+3.5	216		
		-70.0	299.5	-20.0	31		
		-44.0	325.5	+22.5		15	
		-30.0	339.5	-19.5	9		
		-25.5	344.0	-19.0		31	
		+5.0	14.5	-18.5		185	
		+11.5	21.0	-16.0		123	
		+15.5	25.0	-15.5	185		
		+31.0	40.5	+8.5	170		965
Aug. 11 (Mount Wilson)...	13 0	-60.0	295.5	+4.0	201		
		-55.0	300.5	-19.0		21	
		-10.0	345.5	-19.0	15		
		+25.0	20.5	-18.0		428	
		+46.0	41.5	+8.0	207		873
Aug. 12 (Mount Wilson).	14 15	-58.0	283.6	+8.0		39	
		-46.0	295.6	+5.0	188		
		-45.0	296.6	+22.0		25	
		-43.0	298.6	-18.0		30	
		+5.0	346.6	-18.0	10		
		+39.0	20.6	-18.0		418	
		+60.0	41.6	+8.0	237		947
Aug. 13 (Naval Observa- tory).	11 50	-47.5	282.1	+8.0		123	
		-43.0	286.6	+7.0		93	
		-40.0	289.6	-20.0		31	
		-35.5	294.1	+21.0	31		
		-32.5	297.1	+3.5	170		
		-32.0	297.6	-17.5		46	
		-30.5	299.1	+19.5	31		
		-27.5	302.1	-18.5		46	
		+17.0	346.6	-18.5	6		
		+34.0	3.6	-14.0	15		
		+45.0	14.6	-18.5		216	
		+56.5	25.1	-16.0		185	
		+71.0	40.6	+8.5	185		1,178
Aug. 14 (Naval Observa- tory).	11 38	-56.0	260.6	+9.0	22		
		-34.0	282.6	+8.0		77	
		-30.0	286.6	+7.0	93		
		-21.5	295.1	+22.0	9		
		-19.5	297.1	+3.5	170		
		-18.5	298.1	+19.5		31	
		-13.0	303.6	-18.0		25	
		+40.0	5.6	-16.0	46		
		+57.5	14.1	-18.5		123	
		+69.0	25.6	-16.0	185		
		+84.0	40.6	+8.5	154		935
		Aug. 15 (Naval Observa- tory).	11 18	-74.0	229.5	-15.0	31
-42.5	261.0			+9.0	15		
-22.0	281.5			+10.0		62	
-17.0	286.5			+7.5		108	
-6.5	297.0			+3.5		123	
-5.5	298.0			+19.0	9		
+0.5	304.0			-18.0		40	
+33.5	337.0			-16.0		22	
+57.7	1.0			-14.5	93		
+62.5	6.0			-15.0	108		

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longi- tude	Lat- itude	Spot	Group	
1928—Continued							
Aug. 16 (Mount Wil- son).	H. m. 14 0	°	°	°			
		-62.0	226.9	-18.0		247	
		-10.0	278.9	+18.0		5	
		-3.0	285.9	+7.0		52	
		+3.0	291.9	+12.0	5		
		+5.0	293.9	+20.0		9	
		+9.0	297.9	+4.0		175	
		+17.0	305.9	-18.0		10	
		+18.0	306.9	+17.0		5	
		+26.0	314.9	+18.0	4		
		+55.0	343.9	-19.0		19	
		+80.0	8.9	[-15.0]		196	727
Aug. 17 (Naval Observ- atory).	13 57	-52.0	223.6	-13.0		40	
		-49.5	226.1	-19.0		15	
		-49.5	226.1	-10.5	62		
		-45.0	230.6	-15.0		62	
		+10.5	286.1	+7.0		52	
		+22.5	298.1	+3.5		123	
		+29.5	305.1	-18.0	12		366
Aug. 18 (Naval Observ- atory).	11 2	-83.0	181.0	+5.0	216		
		-40.0	224.0	-13.0		62	
		-38.0	226.0	-18.5		25	
		-36.0	228.0	-11.5		77	
		-32.5	231.5	-15.0		46	
		+22.0	286.0	+7.0		31	
		+34.0	298.0	+3.5		123	
		+41.0	305.0	-18.0	12		592
Aug. 19 (Naval Observ- atory).	11 28	-84.0	166.6	-10.0	154		
		-70.0	180.6	+5.0	247		
		-25.0	225.6	-19.0	25		
		-24.5	226.1	-12.0		108	
		-19.5	231.1	-14.5	15		
		+48.0	298.6	+3.0	62		611
Aug. 20 (Naval Observ- atory).	11 40	-70.5	166.8	-10.0	170		
		-57.0	180.3	+4.5	247		
		-12.0	225.3	-12.0		370	
		-9.5	227.8	-19.0		184	
		-5.5	231.8	-14.5	15		
		+01.0	298.3	+2.5	123		1,079
Aug. 21 (Naval Observ- atory).	11 38	-81.0	143.1	+14.5	216		
		-75.0	149.1	-20.0		185	
		-64.5	159.6	-8.5	62		
		-58.0	166.1	-9.5	185		
		-42.5	181.6	+4.5	216		
		-3.0	221.1	+23.5	9		
		+2.0	226.1	-12.5		494	
		+4.0	228.1	-18.5		93	
		+8.5	232.6	-14.5		6	
		+74.5	298.6	+3.0	123		1,589
Aug. 22 (Naval Observ- atory).	11 45	-82.5	128.3	+18.0		154	
		-70.0	140.8	-21.0		93	
		-68.0	142.8	+14.5	185		
		-62.0	148.8	-20.5		123	
		-53.0	157.8	-8.5		62	
		-44.5	166.3	-9.5	123		
		-29.0	181.8	+4.5		201	
		-17.5	193.3	+30.0	18		
		+15.5	226.3	-12.5		463	
		+17.0	227.8	-18.5		154	
		+20.5	231.3	-15.0	6		1,582
Aug. 23 (Naval Observ- atory).	12 0	-71.0	126.4	+17.5		278	
		-57.5	139.9	-21.0		93	
		-54.5	142.9	+14.5	216		
		-47.0	150.4	-20.5	139		
		-38.0	159.4	-8.5	46		
		-30.5	166.9	-9.5	123		
		-16.0	181.4	+4.5		185	
		-4.0	193.4	+30.0	9		
		+26.5	223.0	-13.5		340	
		+31.0	228.4	-18.0		185	
		+31.5	228.9	-10.5	278		1,892
Aug. 24 (Naval Observ- atory).	11 35	-81.0	103.4	+4.5	93		
		-59.5	124.9	+18.0		154	
		-56.0	128.4	+17.0	309		
		-44.0	140.4	-20.5		77	
		-41.5	142.9	+14.5	247		
		-33.0	151.4	-21.0		185	
		-18.0	166.4	-9.5	123		
		-2.5	181.9	+4.5		108	
		+40.0	224.4	-14.0		309	
		+43.5	227.9	-17.5		154	
		+44.0	228.4	-12.0	370		2,129
Aug. 25 (Naval Observ- atory).	13 9	-72.0	98.4	-15.5		154	
		-67.0	103.4	+4.5	108		
		-43.5	126.9	+17.5		494	
		-28.0	142.4	+15.0	184		
		-19.0	151.4	-21.0	139		
		-3.5	166.9	-10.0		93	
		+10.0	180.4	+3.5		62	
		+13.5	183.9	+6.0	46		

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longitude	Latitude	Spot	Group	
1928—Continued							
Aug. 26 (Mount Wilson).	H. m. 11 0	° -60.0	° 98.3	° -15.0		55	
		-56.0	102.3	+5.0	134		
		-31.0	127.3	+18.0		319	
		-18.0	140.3	-16.0		16	
		-16.0	142.3	+15.0	322		
		-8.0	150.3	-22.0	172		
		+8.0	166.3	-10.0		13	
		+22.0	180.3	+5.0		17	
		+64.0	222.3	-14.0		218	
		+72.0	230.3	-7.0	372		1,638
Aug. 27 (Naval Observatory).	13 14	-68.0	75.9	+23.0		123	
		-44.0	99.9	-15.0		93	
		-40.0	108.9	+4.5	123		
		-19.5	124.4	+19.0		278	
		-16.0	127.9	+17.5		93	
		-13.0	130.9	+17.0	139		
		-2.0	141.9	-15.0		31	
		-1.0	142.9	+14.5	123		
		+7.0	150.9	-21.0	108		
		+22.5	166.4	-10.0	31		
		+40.5	184.4	+5.0	31		
		+82.0	225.9	-13.0		463	1,636
Aug. 28 (Naval Observatory).	11 38	-86.0	45.6	+9.0	93		
		-39.0	92.6	-9.5		15	
		-31.5	100.1	-15.5		62	
		-28.0	103.6	+4.5	139		
		-27.5	104.1	-14.0		31	
		-7.0	124.6	+18.0		278	
		-1.5	130.1	+16.0	216		
		+11.0	142.6	+14.5	170		
		+19.0	150.6	-21.0	154		
		+35.5	167.1	-10.0	22		
		+52.5	184.1	+5.0	31		1,211
Aug. 29 (Naval Observatory).	11 41	-80.0	38.3	+20.0	62		
		-72.5	45.8	+8.0	123		
		-70.0	48.3	+18.0	31		
		-18.0	100.3	-15.5		31	
		-13.5	104.8	+5.0	93		
		-13.0	105.3	-14.0		31	
		+7.0	125.3	+18.0		185	
		+22.0	140.3	+16.0	216		
		+24.5	142.8	+14.5	154		
		+31.5	149.8	-21.0	139		
		+49.5	167.8	-10.0	9		1,074
Aug. 30 (Naval Observatory.)	11 39	-67.0	38.1	+20.0	46		
		-59.5	45.6	+8.0	108		
		-57.0	48.1	+18.0	31		
		-4.0	101.1	-15.0		22	
		0.0	105.1	+5.0		93	
		+2.0	107.1	-13.5		31	
		+20.0	125.1	+18.5		93	
		+25.5	130.6	+15.5	185		

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longi- tude	Latitu- de	Spot	Group	
1928—Continued							
Aug. 30 (Naval Obser- vatory)—Continued.	H. m. 11 39	°	°	°			
		+37.5	142.6	-17.0		31	
		+38.0	143.1	+14.5	154		
		+45.0	150.1	-21.5	108		902
Aug. 31 (Mount Wilson).	12 45	-48.0	43.3	+19.0		19	
		-45.0	46.3	+8.0	133		
		+15.0	106.3	+6.0	94		
		+38.0	129.3	+17.0		202	
		+52.0	143.3	+15.0	237		
		+60.0	151.3	-21.0	8		693
Mean daily area for August							1,147
July 23 (Mount Wilson)..	9 30	+81.0	167.7	+7.0		21	
		-44.0	204.7	+14.0		169	
		-38.0	210.7	-20.0		42	
		+35.0	283.7	+5.0		70	
		+45.0	283.7	-20.0		40	
		+50.0	288.7	+9.0		423	
		+75.0	323.7	-22.0		36	801

PROVISIONAL SUNSPOT RELATIVE NUMBERS FOR AUGUST, 1928

(Data furnished by Prof. A. Wolfer, University of Zurich, Switzerland)

August	Relative numbers	August	Relative numbers	August	Relative numbers
1	107	11	73	21	71
2	116	12	74	22	79
3	126	13	90	23	101
4	100	14	89	24	91
5	80	15	73	25	104
6	67	16	76	26	112
7	79	17	58	27	110
8	59	18	41	28	
9	59	19	53	29	
10	80	20	58	30	84
				31	80

Number of observations, 29; mean, 82.4.

AEROLOGICAL OBSERVATIONS

By L. T. SAMUELS

Free-air temperature departures for the month were of only moderate magnitude in practically all cases, being negative in the lower levels at all stations and positive in the higher levels at Broken Arrow, Due West, and Royal Center. (See Table 1.)

It will be noted that positive relative humidity departures occurred with positive temperature departures at a number of upper levels at Broken Arrow and Due West and negative relative humidity departures with negative temperature departures at Groesbeck. It is of interest to note in this connection the exceptionally heavy total monthly rainfall at Broken Arrow (10.11 inches) and Due West (13.90 inches) and the extremely light precipitation at Groesbeck (0.01 inch).

As might be expected, in these cases, the monthly mean free-air vapor pressures were greatly in excess of their normal at Broken Arrow and Due West and below normal at Groesbeck.

The resultant free-air winds for the month were in general close to normal. (See Table 2.)

The wind velocity at Sheridan, Wyo., on the 21st increased from a calm at the surface to 50 m. p. s. at 10 km., the maximum altitude. The direction remained west above 1 km. This observation was taken to the west of the center of a high-pressure area and as might be expected from such a strong wind a very marked change in the pressure distribution occurred during the following 24 hours. The high moved rapidly eastward and was replaced by an extensive depression. A pilot balloon observation made on the 22d at Cheyenne in the southern part of this low revealed a rapid increase in the wind from 7 meters per second at the ground to 42 meters per second at 3 km. The direction was west-southwest throughout.

An observation made at Knoxville on the 9th, at which time a tropical hurricane was centered over Tampa, Fla., indicated a northerly wind up to 2,500 meters superim-

posed by a southerly wind to 5,000 meters. Above this altitude the wind was light and variable. During the following 48 hours the storm center moved northward to about 100 miles east of Knoxville.

On the morning of the 14th when another hurricane was centered over Apalachicola, Fla., the winds at Knoxville were easterly to 5,000 meters. The path of this storm, it is noted, extended farther westward than that of the first storm and the second storm likewise dissipated more rapidly, particularly after it recurved toward the northeast.

TABLE 1.—Free-air temperatures, relative humidities, and vapor pressures during August, 1928

TEMPERATURE (°C.)										
Altitude m. s. l.	Broken Arrow, Okla. (233 meters)		Due West S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)	
	Mean	De- parture from normal	Mean	De- parture from normal	Mean	De- parture from normal	Mean	De- parture from normal	Mean	De- parture from normal
<i>Meters</i>										
Surface	26.0	-0.7	25.7	-0.2	20.0	-0.2	25.3	-1.5	22.2	-1.3
250	25.9	-0.7	25.4	-0.1			25.1	-0.9	22.0	-1.3
500	25.1	-0.2	23.6	+0.5	19.7	-0.3	24.1	-0.2	20.1	-1.1
750	24.2	0.0	22.4	+0.9	18.4	-0.7	23.0	-0.3	18.5	-1.0
1,000	23.0	0.0	20.8	+0.8	17.5	-0.6	22.0	-0.2	17.4	-0.6
1,250	21.8	+0.3	19.3	+0.8	16.4	-0.5	20.7	-0.2	16.3	-0.2
1,500	20.2	+0.3	17.6	+0.6	15.3	-0.2	19.3	-0.2	15.0	-0.1
2,000	16.7	+0.2	14.2	+0.1	12.6	0.0	16.2	-0.4	12.7	+0.4
2,500	13.4	+0.3	11.3	+0.2	9.5	-0.1	13.2	-0.5	10.1	+0.4
3,000	10.2	+0.3	9.1	+0.7	5.8	-0.8	10.4	-0.6	7.4	+0.5
3,500	7.6	+0.9			2.5	-1.2	6.6	-1.7	4.6	+0.4
4,000	4.8	+1.0			-0.7	-1.5			1.6	0.0
4,500	2.2	+1.5			-3.1	-0.9				

TABLE 1.—Free-air temperatures, relative humidities, and vapor pressures during August, 1928.—Continued

RELATIVE HUMIDITY (%)										
Altitude m. s. l.	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)	
	Mean	De- parture from normal	Mean	De- parture from normal	Mean	De- parture from normal	Mean	De- parture from normal	Mean	De- parture from normal
<i>Meters</i>										
Surface.....	77	+10	79	+10	69	+3	81	+8	76	+9
250.....	77	+10	79	+10	69	+3	79	+5	76	+9
500.....	71	+7	77	+6	68	+4	76	+2	74	+10
750.....	67	+5	73	+2	64	+4	67	-1	74	+8
1,000.....	63	+2	73	+2	62	+4	58	-4	71	+5
1,250.....	62	+1	71	0	61	+4	56	-4	68	+2
1,500.....	63	+2	71	+1	59	+2	55	-5	64	-1
2,000.....	70	+7	78	+10	53	-2	58	-1	52	-9
2,500.....	71	+8	75	+8	52	-2	53	-4	43	-12
3,000.....	70	+7	77	+11	58	+4	47	-6	39	-12
3,500.....	47	-13			62	+10	57	+9	35	-12
4,000.....	35	-20			63	+13			32	-14
4,500.....	25	-27			63	+14				

VAPOR PRESSURE (mb.)										
Surface.....	25.60	+2.61	25.90	+3.09	16.27	+1.13	26.13	+0.80	20.59	+1.34
250.....	25.40	+2.59	25.43	+2.95			25.25	+0.73	20.33	+1.30
500.....	22.62	+2.19	22.38	+2.22	15.81	+1.05	22.80	+0.60	18.03	+1.23
750.....	20.19	+1.82	19.80	+1.40	13.82	+0.72	18.99	-0.12	15.76	+0.46
1,000.....	17.63	+0.92	18.06	+1.19	12.58	+0.72	15.70	-0.83	14.04	-0.01
1,250.....	16.24	+0.96	16.16	+0.79	11.43	+0.63	13.95	-0.89	12.57	-0.20
1,500.....	15.09	+1.18	14.45	+0.61	10.24	+0.43	12.57	-0.97	10.79	-0.64
2,000.....	13.33	+1.71	12.87	+1.74	7.80	-0.08	11.01	-0.18	7.32	-1.57
2,500.....	11.02	+1.65	10.33	+1.24	6.19	-0.22	8.48	-0.68	4.97	-1.68
3,000.....	8.82	+1.33	9.17	+1.71	5.51	+0.20	6.50	-0.88	3.93	-1.17
3,500.....	5.06	-0.59			4.56	+0.28	5.93	+0.09	2.74	-1.14
4,000.....	3.34	-0.76			3.54	+0.07			2.09	-1.15
4,500.....	2.12	-0.84			2.71	-0.10				

VAPOR PRESSURE (mb.)

Altitude m. s. l.	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)		Washington, D. C. (34 meters)	
	Mean	Normal	Mean	Normal	Mean	Normal	Mean	Normal	Mean	Normal	Mean	Normal
Surface	25.60	+2.61	25.90	+3.00	16.27	+1.13	26.13	+0.80	20.50	+1.34	25.60	+1.30
250	25.40	+2.50	25.43	+2.95	15.81	+1.05	25.25	+0.73	20.33	+1.30	25.40	+1.23
500	22.62	+2.19	22.38	+2.22	13.82	+0.72	22.80	+0.60	18.03	+1.23	22.62	+1.06
750	20.19	+1.82	19.80	+1.40	12.58	+0.72	18.99	-0.12	15.76	+0.46	20.19	+0.01
1,000	17.63	+0.92	18.06	+1.19	12.58	+0.72	15.70	-0.83	14.04	-0.01	17.63	-0.20
1,250	16.24	+0.96	16.16	+0.79	11.43	+0.63	13.95	-0.89	12.57	-0.20	16.24	-0.64
1,500	15.09	+1.18	14.45	+0.61	10.24	+0.43	12.57	-0.97	10.70	-1.57	15.09	-1.68
2,000	13.33	+1.71	12.87	+1.74	7.80	-0.08	11.01	-0.18	7.32	-1.17	13.33	-1.17
2,500	11.02	+1.65	10.33	+1.24	6.19	-0.22	8.48	-0.68	4.97	-1.14	11.02	-1.14
3,000	8.82	+1.33	9.17	+1.71	5.51	+0.20	6.50	-0.88	3.93	-1.17	8.82	-1.14
3,500	5.06	-0.59			4.56	+0.28	5.93	+0.09	2.74	-1.14	5.06	-1.14
4,000	3.34	-0.76			3.54	+0.07			2.09	-1.15	3.34	-1.15
4,500	2.12	-0.84			2.71	-0.10					2.12	-1.15

TABLE 2.—Free-air resultant winds (m. p. s.) during August, 1928

Altitude m. s. l.	Broken Arrow, Okla. (233 meters)				Due West, S. C. (217 meters)				Ellendale, N. Dak. (444 meters)				Groesbeck, Tex. (141 meters)				Royal Center, Ind. (225 meters)				Washington, D. C. (34 meters)			
	Mean		Normal		Mean		Normal		Mean		Normal		Mean		Normal		Mean		Normal		Mean		Normal	
Meters	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°
Surface	S. 9 W.	3.0	S.	3.2	S. 78 W.	2.2	N. 78 W.	0.5	S. 21 E.	0.6	S. 23 W.	0.8	S. 18 W.	2.6	S. 17 W.	3.1	N. 6 W.	0.5	S. 56 E.	1.1	S. 81 W.	0.4	N. 37 W.	0.5
250	S. 10 W.	3.4	S.	3.4	S. 76 W.	2.4	N. 80 W.	0.6	S. 19 E.	1.1	S. 14 W.	1.2	S. 18 W.	4.1	S. 18 W.	4.2	N. 29 W.	0.4	S. 58 W.	1.3	S. 85 W.	1.6	N. 58 W.	1.2
500	S. 15 W.	5.5	S. 11 W.	4.9	S. 82 W.	3.7	N. 79 W.	1.1	S. 4 E.	3.0	S. 21 W.	2.5	S. 24 W.	5.9	S. 22 W.	5.8	S. 81 W.	1.1	S. 65 W.	2.9	N. 65 W.	2.8	N. 53 W.	1.9
750	S. 21 W.	6.0	S. 19 W.	5.5	S. 84 W.	3.8	N. 77 W.	1.3	S. 16 W.	3.6	S. 36 W.	2.7	S. 26 W.	6.6	S. 22 W.	6.1	S. 38 W.	1.9	S. 72 W.	3.8	N. 52 W.	3.5	N. 50 W.	2.0
1,000	S. 28 W.	5.8	S. 27 W.	5.6	S. 88 W.	4.4	N. 83 W.	1.6	S. 30 W.	4.0	S. 46 W.	3.1	S. 26 W.	6.8	S. 22 W.	6.0	N. 80 W.	3.5	S. 79 W.	4.7	N. 58 W.	3.5	N. 55 W.	3.0
1,250	S. 33 W.	5.3	S. 35 W.	5.4	S. 89 W.	4.1	N. 87 W.	2.0	S. 30 W.	4.0	S. 46 W.	3.1	S. 22 W.	6.5	S. 20 W.	5.4	N. 82 W.	5.4	S. 84 W.	5.4				
1,500	S. 42 W.	4.4	S. 42 W.	5.4	S. 80 W.	4.4	W.	2.9	S. 47 W.	4.6	S. 59 W.	3.5	S. 19 W.	5.9	S. 17 W.	4.7	N. 84 W.	6.5	S. 89 W.	6.2	N. 67 W.	4.8	N. 62 W.	4.2
2,000	S. 51 W.	3.3	S. 50 W.	4.8	S. 75 W.	4.2	N. 87 W.	3.7	S. 58 W.	5.6	S. 74 W.	4.7	S. 15 W.	3.4	S. 12 W.	3.9	N. 79 W.	6.9	S. 89 W.	7.1	N. 75 W.	6.7	N. 66 W.	5.0
2,500	S. 49 W.	2.9	S. 54 W.	4.8	S. 84 W.	5.7	N. 89 W.	4.9	S. 67 W.	7.4	S. 85 W.	8.1	S. 14 W.	5.5	S. 14 W.	3.8	N. 82 W.	6.9	N. 86 W.	8.4	N. 77 W.	6.3	N. 72 W.	6.3
3,000	S. 48 W.	3.2	S. 55 W.	5.2	N. 85 W.	8.3	N. 89 W.	6.5	S. 74 W.	8.9	S. 89 W.	8.6	S. 25 W.	4.5	S. 22 W.	3.6	S. 85 W.	8.7	N. 85 W.	9.8	N. 79 W.	6.5	N. 73 W.	7.0
3,500	S. 41 W.	2.6	S. 52 W.	6.2					S. 78 W.	9.0	N. 85 W.	11.1	S. 5 E.	1.0	S. 25 W.	3.6	S. 85 W.	10.1	N. 86 W.	11.0	N. 71 W.	6.9	N. 72 W.	7.5
4,000	S. 35 W.	3.2	S. 61 W.	7.1					W.	12.2	N. 83 W.	11.8	S. 45 W.	7.0	S. 48 W.	3.0	S. 75 W.	10.8	N. 87 W.	12.1	N. 74 W.	7.3	N. 71 W.	7.7
4,500	N. 13 W.	1.3	S. 82 W.	7.5																	N. 82 W.	7.1	N. 76 W.	7.4
5,000	N. 56 W.	1.2	N. 81 W.	8.4																	N. 83 W.	7.8	N. 72 W.	7.1

WEATHER IN THE UNITED STATES

THE WEATHER ELEMENTS

By P. C. DAY

GENERAL CONDITIONS

Viewing the country as a whole, August weather was not greatly at variance with normal conditions, though locally wide departures therefrom are found; these, however, were confined mainly to moisture conditions, as temperatures were chiefly moderate.

Over extensive areas near the south and middle Atlantic coasts precipitation was unusually heavy on several occasions, exceeding all previous records in some cases, and similar conditions existed over considerable areas in the upper Mississippi Valley and near-by sections, though here the precipitation was more frequent and not so heavy in individual storms.

PRESSURE AND WINDS

The average atmospheric pressure was generally higher than normal in all parts of the country and materially higher than in July preceding.

The month opened with low pressure existing in the upper Missouri Valley and during the following few days rainy conditions overspread most Northern States to the eastward with heavy falls locally over much of the upper Lake region and nearby areas of the upper Mississippi and lower Missouri Valleys. At the same time, considerable rain occurred in the form of local showers in parts of the Southeast.

By the morning of the 7th a tropical storm, moving from the West Indies, approached the east coast of Florida and during the following two or three days crossed the State in a northwest direction, attended by torrential rains and high winds, reaching the northern limits by the morning of the 10th, where it recurved sharply and moved thence northeastward over the South Atlantic States during the 11th, passing into the Atlantic near the mouth of Chesapeake Bay during the following day. The storm was attended by high winds and heavy rains not only in Florida but in its passage over the central and southern parts of Georgia and South Carolina, the winds diminishing somewhat with the advance of the storm, but heavy rains continued throughout its entire course, reaching high intensities in portions of Virginia and Maryland, particularly in the vicinity of the District of Columbia, where the 24-hour fall on the 11th and 12th was the greatest of record. Much damage to crops, roads, and bridges occurred throughout the course of this storm—in Florida by injury to the citrus and other crops, in the eastern cotton States by damage to open cotton, and in all sections by flattening corn, tobacco, and other crops, blowing fruit from trees, flooding and washing of farm land, roads, etc., and otherwise.

Immediately following this a second tropical storm appeared over the west Florida coast on the morning of the 13th, and by the following morning it was central near Apalachicola, Fla., moving northward and attended by high winds and heavy rains. This storm moved in a track slightly west of that of the preceding few days and was attended by heavy rains over much of the territory affected by the earlier storm, though the winds were generally not so high. By the morning of the 16th the storm center had reached the southern Appalachian

region, attended by further heavy rains, whence it moved northeasterly during the following day, heavy rains still continuing, and merged into a general low-pressure area passing along the northern border. Further details of these storms, with estimates of damage, etc., will be found in other sections of this issue.

During the occurrence of the storm last referred to in the more eastern districts fair weather was the rule to the westward, though low-pressure condition set in over the central valleys about the 18th and overspread the South-eastern States during the 19th and 20th, attended by local rains.

On the 20th cyclonic conditions appeared over the middle Missouri Valley and by the following morning had moved to the northward of the Great Lakes and heavy rain had fallen over much of the intervening territory, the precipitation area extending southward into the lower Ohio Valley.

On the morning of the 23d general low barometric pressure covered the territory from northern Texas to Lake Superior and precipitation had occurred during the previous night from eastern Kansas and western Missouri northward to Minnesota and Wisconsin, the falls being heavy in portions of Iowa and Wisconsin. During the following 24 hours the storm moved to the northward of the Great Lakes and the precipitation area extended from the southern mountain and Great Plains area northeastward to the lower Ohio Valley and Great Lakes. The rain area extended slowly eastward during the following two or three days. Immediately following this storm area low pressure again developed over the Northwest and by the 27th scattered rains had fallen in the northern Rocky Mountain area and to the eastward as far as the upper Mississippi Valley. This cyclone moved rapidly to the northward of Lake Superior within the following 24 hours, but precipitation became much lighter than during the preceding day.

The last few days of the month brought extensive precipitation over the more northern districts from the upper Missouri Valley eastward, the area of rainfall extending southward into the Ohio Valley and southwestward to Texas and thence eastward over most districts to the Atlantic coast as the month closed.

No important cyclone entered the Pacific Coast States during the month, though several appear to have had their origin in the northern plateau.

The anticyclones were mainly feeble and exerted no important control of the weather save on the 23d and 24th, when high pressure favored sharp falls in temperature over the northern Rocky Mountains and eastward to the Mississippi Valley.

Save for the two tropical disturbances that brought high winds and severe local storms of tornadic character over the southeastern districts no widely extended storms occurred, though local disturbances were reported in many sections from the Rocky Mountains eastward, some assuming tornado forms and causing loss of life and extensive damage to buildings and crops. A list of the more important of these with the usual descriptive items appears at the end of this section.

TEMPERATURE

No severe heat or cold marked the temperature during the month and the daily changes and departures of

monthly means from normal were not pronounced to any extent, though at a few points in southern New England and adjacent portions of New York the monthly means were the highest of record for any August.

The average temperatures for the month were moderately above normal from the middle Plains eastward to the Atlantic coast and over portions of the plateau region, elsewhere they were slightly less than normal. The warmest sections for the month as a whole as compared with the normal embraced the area from the Lake region eastward to the Atlantic coast, but even here the positive departures were only slightly above 2° , the greatest, $+4.7^{\circ}$, occurring at New Haven, Conn. The negative departures were mainly less than 2° .

Considering the temperature by weekly periods, the first week was mainly warmer than normal over the eastern half of the country, and cooler than normal in the west, being from 4° to 7° in the plateau. The second week was likewise warmer than normal over most States, particularly in Montana, the Dakotas, and other near-by areas, where the positive departures ranged from 6° to 9° per day. This week had average temperatures slightly less than normal in the southern Rocky Mountain areas, over Florida and near-by portions of Georgia and South Carolina and from central Virginia to western New York. The week ended August 21 continued moderately warm over the greater part of the country, though the first part was cool over the far Northwest, where the week as a whole was cooler than normal, and the latter part was moderately cool in most northern districts.

The last 10 days had cool weather for the season over most sections from western Texas northeastward to the lower Lakes and thence westward to the Pacific, save for a few small areas, the period as a whole being from 3° to 6° cooler than normal from the upper Mississippi Valley westward to Idaho. Over districts from central Texas northeastward to New England this period was moderately warmer than normal and this condition to a less extent existed over most other eastern States.

The warmest period over most districts was about the 9th to 11th, when temperatures rose to 100° or slightly above at one or more points in nearly all the States. The warmest day of the month, however, was the 1st, with a maximum temperature of 121° at a point in the desert region of southern California.

Minimum temperatures for the month occurred on various dates, but mainly during the last decade, when temperatures went below 32° at exposed points in all northern districts from Michigan westward and they were below 32° at exposed points in all western mountain districts. The lowest recorded, 15° , occurred in the mountains of Wyoming on the 17th, while 22° was recorded in the mountains of California as early as the 4th.

Light to killing frosts occurred only at a few exposed points in the principal agricultural districts and no important damage resulted.

PRECIPITATION

As stated elsewhere, the rainfall was abnormally heavy over portions of the Eastern and Southeastern States, due to the occurrence of two tropical storms which, as usual, brought excessive rains. These storms, occurring only a few days apart and covering much of the same region, caused unusually high waters in some of the streams of the States affected, full accounts of which appear elsewhere.

Generally speaking, precipitation was well distributed during the month over the eastern half of the country, with large excesses in most of the Atlantic Coast States and in portions of the upper Mississippi Valley and near-by areas. The greatest amount reported was 22.19 inches at a point in Florida, but amounts above 20 inches were reported at several other points in the Southeast, notably in Georgia and the Carolinas. At Macon, Ga., the monthly amount, 20.52, was more than 16 inches above normal. At points in northern Iowa and over near-by areas in Minnesota and Wisconsin the monthly falls exceeded 12 inches, being in some cases the greatest ever recorded in August.

There were well-marked deficiencies, however, in a number of areas, notably in the immediate coast districts from Georgia to southern New England where deficiencies ranged up to nearly 5 inches, in contrast with excesses immediately back from the coast ranging up to 16 inches.

Rather droughty conditions existed over portions of southern Illinois and other parts of the Ohio Valley, in portions of eastern Texas and northern Louisiana, and the month was notably dry over the far Northwest, where unirrigated crops, as well as in other parts of the West, suffered from lack of rain. The distribution of precipitation over the various parts of the country and the departures from normal conditions are graphically shown on Chart V and inset thereto.

SNOWFALL

Snow was reported from a few points in the high mountains of the West, 3 inches being reported from Colorado, 2 inches from northwestern Montana, and traces at a few other points.

RELATIVE HUMIDITY

The percentages of relative humidity were moderately above normal over nearly the entire eastern half and below over the western half, distinctly so in portions of the Rocky Mountain and plateau regions.

SUNSHINE

The sunshine percentages were moderately high over nearly all districts save in the Atlantic Coast and in the southern portions of the East Gulf States, where locally they were less than 40 per cent of the possible and in a few instances less than 30 per cent. In the Great Valley of California they ranged up to nearly 100 per cent of the possible.

SEVERE LOCAL STORMS, AUGUST, 1928

The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the annual report of the chief of bureau.

Place	Date	Time	Width of path, yards ¹	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Denver, Colo.	1	P. m.				Small tornado.	Large trees uprooted; poles and wires damaged.	Official, U. S. Weather Bureau.
Campbellsport, Wis.	1	3:30 p. m.			\$29,360	Severe electrical.	2 large barns burned.	Do.
Carson, Wis. (near)	1	4:30 p. m.			6,500	Wind and hail.	Crops and farm buildings damaged.	Do.
Beldenville, Wis. (near)	1	5:30 p. m.	1,320		10,000	Hail.	Crops and windows considerably damaged; poultry injured.	Do.
Grand Junction, Colo.	2	1:20 - 1:30 p. m.	1-2 mi.		15,000	do.	Crops injured; other property damaged.	Do.
Floyd County, Iowa	2	5 p. m.			75,000	Wind and hail.	Severe property damage.	Do.
Wisconsin (southwestern)	3				67,000	Hail, rain, and wind.	Extensive damage to buildings, highways and bridges.	Do.
Morrell, Nebr.	4	4 p. m.	1,320		15,000	Hail.	Crops damaged.	Do.
Burley, Idaho (near)	4				15,000	do.	Chief damage to grains.	Do.
Stanton and Cuming Counties, Nebr.	6	2:30 p. m.	2 mi.		50,000	do.	Damage principally to corn over a path 6 miles long.	Do.
Harrison, Osceola, and Plymouth Counties, Iowa.	6	4-5:30 p. m.	6 mi.		420,000	Wind and hail.	Heavy property damage over path 30 miles long.	Do.
Florida to New Jersey.	7-13					Tropical hurricane	Scores of buildings unroofed, others wrecked; much citrus fruit ruined; highways, railways, and other public utilities suffer much damage; timberlands hard hit; some lives lost.	Do.
Platte County, Nebr. (northeastern).	8	3-6 p. m.	3 mi.			Hail.	Corn damaged 10 to 50 per cent in places.	Do.
Boone County, Nebr.	8	3:30 p. m.	1,760		6,000	do.	Crops damaged; path 10 miles long.	Do.
Adams and Cumberland Counties, Pa.	8	8-9 p. m.			25,000	Electrical and rain.	Several barns destroyed; considerable crop damage.	Do.
Viola, Wis. (near)	8	8:50 p. m.	1,730		6,000	Hail.	Crops injured.	Do.
Vernon County, Wis. (northwest).	8		1,760		15,000	do.	Damage chiefly to tobacco.	Do.
Lancaster, Pa.	10	3-5 p. m.			100,000	Hail, rain, and wind.	4 barns destroyed; telephone service impaired; some loss to tobacco crop.	Do.
Nixon, Tex. (near)	10	5:30 p. m.				Probably a tornado.	Several small buildings overturned, others unroofed; small trees broken.	Do.
Batesbury, S. C. (near)	10	6:30 p. m.	35	2	6,000	Tornado.	Some property damage; 9 persons injured.	Do.
Newberry, S. C.	10	9 p. m.			25,000	do.	Considerable property damage.	Do.
Towanda, Pa., and vicinity.	10	P. m.			50,000	Electrical, wind, and rain.	12 bridges wrecked; roads washed; much crop damage.	Do.
Boone County, N. Y. (western).	10					Thunderstorm and winds.	Many trees uprooted; small buildings overturned; roofs damaged; crops injured.	Do.
Toledo, Ohio.	10					do.	Overhead wire systems damaged; traffic crippled.	Do.
Green County, N. C. (eastern).	11	3:30 a. m.	150	1	50,000	Tornado.	A number of frame houses and barns totally destroyed.	Do.
Atlantic coast, Florida to southern New England.	12-17					Tropical hurricane	Heavy damage to buildings, overhead wire systems, highways, etc.; a number of lives lost.	Do.
Charleston, S. C.	15	5 a. m.	33		4,000	Tornado.	Slight damage to buildings over path about 700 yards long.	Do.
Little Mountain, S. C.	15	1 p. m.	10		6,000	do.	Damage to property over 3-mile path.	Do.
Newberry County, S. C. (lower).	15	do.			30,000	do.	Considerable property damage reported.	Do.
Bath, S. C.	15	5:30 p. m.	100		5,000	do.	Property damaged over short path; 2 persons injured.	Do.
Grand Junction, Colo.	15	7 p. m.	440		6,000	Hail.	Damage chiefly to crops.	Do.
Ashley Heights, N. C.	16	4:15 a. m.	175	2	50,000	Tornado.	Some frame and small brick buildings wrecked; 10 persons injured; path 800 yards.	Do.
New York (central)	16					Wind, rain, and electrical.	Cellars flooded; public utilities paralyzed; buildings damaged.	Do.
Lookout Mountain, Tenn., to Oglethorpe, Ga.	17	P. m.				Wind and thunderstorms.	Considerable damage to wires; timber and buildings.	Do.
Ida, Kossuth, Plymouth, Pottawattamie, Sac, Sioux, and Woodbury Counties, Iowa.	19	3-5 a. m.			985,000	Wind and hail.	Extensive crop and property damage.	Do.
Fairview, S. Dak.	19	3 a. m.	5 miles.		10,000	Hail.	Much injury to crops.	Do.
Murphy to Phillips, Nebr.	19	4 p. m.				Wind, rain, and hail.	Extensive crop damage.	The Star (Lincoln, Nebr.).
Montgomery, Ala. (near)	19				500	Probably small tornado.	Garage wrecked.	Official U. S. Weather Bureau.
Worth County, Iowa (northwest), to Austin, Minn.	20	4:45 p. m.		6	1,000,000	Tornado.	Many buildings demolished; crops ruined; 60 persons injured.	Do.
Twin Lakes, Calhoun County, Iowa.	20	5 p. m.	440	2	150,000	do.	Heavy crop and property damage over path 5 miles long.	Do.
Webster, Hamilton, Story, Pocahontas, and Hardin Counties, Iowa.	20	P. m.		3	175,000	5 tornadoes.	Heavy damage to farm and city property; many persons injured.	Do.
Wisconsin (southern)	20	1-10 p. m.			338,500	Wind, hail, and a small tornado.	Farm property, wire systems, trees, etc., suffered severely; tornado in La Crosse County.	Do.
Clinton, Dubuque, Linn, and Marshall Counties, Iowa.	20	3-10 p. m.			50,000	Wind and hail.	Crops and telephone lines damaged.	Do.
Shannon, Ill.	20	9:30 p. m.	100		10,000	Tornado.	Several buildings wrecked or damaged; many trees uprooted; path 2 miles.	Do.
Portage, Mahoning, and Trumbull Counties, Ohio.	21					Violent wind and thunderstorm.	Crops and wires damaged; streets and basements flooded; traffic demoralized; heaviest damage in Warren.	Do.
Taylor, N. Y.	21					Severe wind.	Homes, barns, and other small structures damaged.	Do.
Pueblo, Colo. (near)	21	P. m.				Hail.	Growing crops and orchards badly damaged.	Do.
Paxton, Nebr.	22	3 p. m.	1,760		35,000	do.	Severe damage to crops in places over path 6 miles long.	Do.
Burwell, Nebr.	22	6 p. m.	6 mi.		10,000	do.	Corn badly injured.	Do.
Cerro Gordo, Hancock, Howard, Kossuth, Mitchell, Pocahontas, and Worth Counties, Iowa.	22	P. m.				Hail and wind.	Extensive property damage reported.	Do.
Vineland, Colo., and vicinity.	22	do.			90,000	Hail.	Cucumbers, cantaloupes, and watermelons totally destroyed; other crops beaten.	Do.

¹ "Mi." signifies miles instead of yards.

Severe local storms, August, 1928—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Yankton, S. Dak.	22				\$100,000	Severe thunder-storm.	Many buildings damaged.	Official U. S. Weather Bureau
Scottsbluff County, Nebr.	24	4 p. m.	6 mi.		30,000	Hail.	Beets, potatoes, and corn badly damaged; path 12 miles.	Do.
Lyman, Nebr.	24	9 p. m.	1,760		15,000	do.	Beet crop injured.	Do.
Fort Cook and Bellevue (near), Nebr.	25	4:15 p. m.	60-440		31,000	Tornado.	Buildings on 4 farms wrecked; 1 person injured; path 5 miles.	Do.
Omaha, Nebr.	25	5 p. m.	440-880		65,000	High wind.	Buildings, orchards, vineyards, and crops hurt.	Do.
Pottawattamie, Mills, Montgomery, Cass, and Adair Counties, Iowa.	25	5:30-8 p. m.		4	625,000	5 tornadoes.	Buildings wrecked; crops ruined; livestock killed.	Do.
Phoenix, Ariz.	26	6 p. m.			100,000	Rain, hail, and wind.	Many homes and business houses damaged; communication lines down.	Do.
Moline Airport, Ill.	28	2:45 a. m.			15,000	Tornado.	2 steel towers demolished.	Do.
Alpha, Mich.	28	A. m.				Thunderstorm and wind.	Buildings, trees, and grain damaged; power and telephone service interrupted.	Do.
Bessemer, Mich.	28			2		Wind.	Character of damage not reported.	Do.
Granville, Ill. (near)	29	1:30 p. m.			1,000	Tornado.	Several farm buildings damaged or demolished; trees prostrated.	Do.
Starved Rock, Ill.	29	3 p. m.	440			do.	About 100 trees uprooted or twisted off; path 4 miles.	Do.
Philadelphia, Pa.	30	6:50 p. m.		1		Severe electrical.	Numerous accidents caused by falling trees; traffic obstructed.	Do.
Rocky Ford, Colo.	31	5 p. m.	5 mi.		100,000	Hail.	Heavy crop loss, chiefly to cantaloupes.	Do.

RIVERS AND FLOODS

By H. C. FRANKENFIELD

Atlantic drainage.—Heavy local rains on August 26-27 over western Massachusetts and northwestern Connecticut caused rapid rises in the lower Connecticut River and its tributary streams. An advisory warning for the former was issued accordingly and a rise of 8.9 feet occurred at Hartford, Conn., by 4 p. m. August 27. No damage occurred along the river, and was only moderate along the tributary streams. Some highways were overflowed, and there was some suspension of electric-line service.

A tropical storm prevailing at the time caused heavy rainfall from August 10 to 12 over the valley of the James River of Virginia, the amounts averaging nearly 6 inches. Stages considerably above the flood line occurred from the mouth of the Rivanna River eastward on August 11 and 12 followed by a rapid decline.

Growing crops, principally corn, were damaged and in some lowlands washed out. On August 16, another heavy rainfall, ranging from 1 to 4 inches caused a second and greater rise on account of the saturated condition of the soil and on the morning of August 17 warnings were issued. There were no floods from Lynchburg, Va., westward, but to the eastward the crest stages were from 7 to nearly 9 feet above the flood stages. Much portable property, including livestock, was removed to places of safety. Reported losses were \$104,000 of which \$40,000 were in crops, and two men were reported drowned. Value of property saved through warnings, \$32,000.

Under the influence of the same general rain conditions above mentioned floods occurred in the Roanoke river and the rivers of central and eastern North Carolina generally. The Roanoke River at Randolph, Va., reached a stage of 31.6 feet at 4 p. m., August 13, and a stage of 31.2 feet at 1 p. m., August 18, flood stage being at 21 feet. The only higher stage of record was 34 feet at 10 p. m., December 30, 1901 (U. S. G. S.).

The rises in the Neuse, Tar, and Cape Fear Rivers were not of much consequence, except in the lower Cape Fear River. In this section Elizabethtown, N. C., reported a 4-day rise with a crest of 26 feet, 4 feet above the flood stage, on August 9. A third rise in the lower river followed a heavy 1-day rain and the river at Elizabethtown was above the flood stage of 22 feet from the evening of August 23 until the early morning of August 26. The usual warnings

were issued for all rises. Damage and loss as reported amounted to \$300,000, of which \$250,000 was in crops. Reported value of property saved through warnings, \$175,000.

From the same conditions of heavy rains, floods also occurred throughout the State of South Carolina. They were not severe over the drainage area of the Pee Dee River, but throughout the Santee system and along the Savannah River they were disastrous.

The floods in the Pee Dee River system were not severe, although along the extreme lower reaches of the Pee Dee River the crests were considerably above the flood stages. Reported losses were only \$12,000, while the reported value of property saved through the warnings was \$101,000.

Numerous warnings for these floods were disseminated at the proper time, and ample opportunity was afforded for the removal of livestock and portable property in general. In the Santee River there was only a single flood, with, however, a brief pause on August 18, but above the junction of the Wateree and Santee Rivers there were two, the first, however, much smaller than the second.

During the period from August 10 to 18, the average rainfall over the Santee Basin from the two tropical storms was as follows: Coastal plain, 4.10 inches; central counties, 7.10 inches; and Piedmont section, 11.29 inches; the apex covering Spartanburg and Greenville Counties. The floods resulting from the first rain period, August 10-11, did not extend to the Catawba-Wateree Basins, and were only moderate in the Saluda area, while in the Broad and Congaree Basins they were severe with crest stages from 9.5 to 13.5 feet above the flood line. The Santee flood set in during August 12.

The second floods from the additional heavy rains of August 15-16 were remarkable for the general high stages attained and for their destructiveness. On account of the breaking of a power dam across Broad River at Lockhart, about 30 miles above, the water at Blairs reached a stage at 2 p. m. August 17 of 40 feet, 25 feet above the flood stage and 3.1 feet above the previous high-water record of July 16, 1916. The Congaree River at Columbia reached 33.5 feet, or 18.5 feet above the flood stage at 2:30 a. m. August 18. This was 2.3 feet below the high-water mark of August 27, 1908, but it was stated that in 1908 the flow was somewhat retarded by the lower works of the old highway bridge, while in 1928 there was a freer flow beneath the new bridge. Warnings of both floods were timely and

accurate. At times, especially following the failure of the dam at Lockhart, when communication was interrupted, the absence of reports complicated the forecasting problem somewhat but the results were entirely satisfactory. During the flood there were about 4,000 telephone calls for information made upon the Columbia office of the Weather Bureau.

The total losses as reported were \$2,423,213; miscellaneous, \$1,405,534; crops \$937,700; livestock and other movable property, \$25,759; and suspension of business \$54,220. Reported value of movable property saved through the warnings, \$361,525.

On August 17 at 9 p. m. the Savannah River at Augusta, Ga., reached a stage of 40.4 feet, the highest stage of record. The actual discharge at this stage was only 196,000 second-feet, whereas on August 27, 1908, with a stage of 38.8 feet, or 1.6 feet less, the discharge was 325,000 feet. On March 16, 1912, with a stage of 36.8 feet, the discharge was 215,000 feet.

The flood was the first of great magnitude since the completion of the Augusta protective levee in 1913, and afforded the first opportunity to obtain data regarding the action of the river within its restricted channel, which is narrowed both by the levee on the Augusta side and by the Hamburg Road on the South Carolina side so that the waters can not spread out again until they have passed the Charleston and South Carolina bridge about 4 miles downstream. The problem is under investigation by a group of engineers, and their conclusions are awaited with interest.

At and above Augusta the loss and damage were not great, possibly between \$50,000 and \$75,000. About 300 negroes in Hamburg, S. C., were forced to abandon their homes temporarily. In the swamps and lowlands below Augusta, on both sides of the river, the losses in crops, livestock, farm property, etc., were at least \$1,000,000.

Warnings were issued as soon as required and the estimated value of savings resulting therefrom is \$1,000,000. Owing to the uncertainty as to the effect of the new levees upon the stages of the river at Augusta, the estimate of the crest stage was somewhat conjectural. However, the warnings called for a very high stage.

The floods in the Altamaha River system of Georgia were serious, and during the second rise the Oconee River at Milledgeville reached a stage of 41.1 feet on August 16, 19.1 feet above the flood stage, and 4.4 feet above the previous high-water record of January 19, 1925.

The first rise began on August 10, when the tropical storm was central over southwest Georgia and the average rainfall for August 10 and 11 was nearly 4 inches, of which by far the greater portion fell over the central and lower portions of the damage area. At Macon on the Ocmulgee River 7.99 inches fell during the 24 hours ending at 8 a. m., August 11, and at Milledgeville on the Oconee River 5.66 inches fell during the same period. Over the Altamaha drainage below Lumber City the fall was much less. The response in the rivers was, of course, immediate, with a 24-hour rise of 25.7 feet at Milledgeville by 8 a. m., August 11, followed by a rapid fall to 14.1 feet by 8 a. m., August 14, by which time a second tropical disturbance had brought another very heavy rain with an average fall on August 14-15 of about 6 inches over the Oconee and nearly 5 inches over the Ocmulgee drainage. As before, the fall over the Altamaha basin proper was much less, a very fortunate circumstance, as an equivalent fall might easily have caused a repetition of the disaster of January, 1925.

During the second rise the Oconee River at Milledgeville reached its record stage of 41.1 feet on August 16, a rise of 27 feet in 2 days. At Dublin there was virtually but one rise with a crest of 27.9 feet, or 5.9 feet above the flood stage, on August 19.

The first Ocmulgee River rise was not important, and there were no flood stages reached except on August 11 at Macon, where there was a crest of 20.9 feet, or 2.9 feet above the flood stage, at 6 p. m. The second rise was more pronounced, although flood stages were not greatly exceeded except along the lower reaches where the average excess was between 5 and 6 feet.

The Altamaha flood was also limited to a single rise, and was quite pronounced over the upper and lower sections, although only moderate between as indicated by the crest of 11 feet at Doctortown. At Charlotte, above, the crest of 26.2 feet on August 22 was 11.2 feet above the flood stage, and at Everett City, below, the crest of 15 feet on August 27 and 28 was 5 feet above the flood stage.

On account of low banks the overflow water covered wide areas, such as 1 mile at Abbeville and 2 miles at Lumber City, both from the Ocmulgee River, 5 to 6 miles at Toombsboro and 1 to 2 miles at Mount Vernon from the Oconee River and 5 to 6 miles at Jesup and 8 miles at Gardi from the Altamaha River.

Warnings for the floods were issued promptly and given wide distribution.

Very incomplete reports indicated losses and damage to the amount of \$532,275, of which \$164,350, was in buildings, highways, etc., \$25,175 in livestock and other movable property, \$192,150 in crops and \$150,600 on account of enforced suspension of business. The reported value of property saved through the warnings was \$325,450.

There was but a single rise in the rivers of the Apalachicola system of the South. It was moderate, was forecast at the proper time and no damage was reported. The only flood stage occurred in the Flint River at Albany, Ga.

MISSISSIPPI DRAINAGE

Ohio Basin.—The heavy mid-month rains also caused severe floods in the French Broad River of North Carolina and Tennessee, especially at Asheville, N. C., and adjacent sections. The floods were of the destructive character incident to mountainous regions, and the damage probably amounted to several hundred thousands of dollars. There was also much crop damage. At Asheville the crest stage of 12 feet at 11 a. m. August 16 was 8 feet above the flood stage and the highest stage since the memorable flood of July, 1916.

Missouri Basin.—Heavy rains during the closing days of July and the early days of August were followed by extensive overflows in the Smoky Hill, Solomon, and Saline Basins of Kansas. In addition to enormous damage to crops, bridges, State roads and railroads suffered greatly. The greatest damage was experienced at Salina, where the crest of the Saline River flood on August 9 was only 21½ inches lower than that of the great flood of 1903. In the eastern portion of the city 48 blocks were flooded, in some places to a depth of several feet and the overflow continued for several days.

Losses in the Solomon Basin were estimated at \$1,349,000, of which \$999,000 was in crops, \$25,000 in livestock, \$245,000 in bridges and highways and \$80,000 on account of suspension of business. In the Smoky Hill and Saline Basins the estimated damage was \$1,477,000, of which \$1,081,000 was in crops, \$41,000

in livestock, \$310,000 in bridges and highways and \$45,000 on account of suspension of business. The total loss reported was \$2,826,000. Railroad losses are not included in this total. Warnings were issued when the first heavy rains were reported, and repeated daily until the floods subsided. No report was made as to savings made through the warning service. A minor flood in the Grand River of Missouri between August 4 and 6 passed off without damage. The usual warnings were issued.

Arkansas drainage.—Heavy local rains on August 3-4 caused a moderate flood in the Arkansas River between Webbers Falls, Okla., and Fort Smith, Ark., and a decided rise below the latter point. There was also a moderate flood in the lower Neosho River of Oklahoma. Warnings were timely and only \$6,000 damage was reported, with savings through the warnings of an equal amount.

At least once in every summer torrential rains cause destructive overflows of small streams within a comparatively limited area, and usually the resulting damage is proportionately greater than that attending floods in large rivers.

Thus it happened on August 26 and 27 over the Catskill Mountains of New York and the district to the south-eastward and southward. The rains were followed immediately by extensive overflows of the streams in the district, and especially of Rondout Creek, the waters from which were responsible for the loss of three lives and an enormous amount of damage, probably as much as \$2,000,000.

There is, of course, no river service in this section, and definite information was not available.

THE FLOODS OF JULY, 1928, IN THE MISSISSIPPI AND ATCHAFALAYA RIVERS

These floods resulted from a sustained rise in the two rivers that began near the middle of June and culminated after the middle of July. The stages reached were the highest of the present year, and marked the latest recorded dates for annual maximum stages as well as the highest stages at such late dates. Even higher stages would have resulted had it not been for the large reduction from evaporation during the summer season, especially the hot and dry weather of the first decade of July.

While the floods were not more than moderate so far as stages were concerned, there was probably considerable damage due to backwater, such as occurred through the Henderson Crevasse in St. Martin Parish, La.

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC DRAINAGE					
James River:	<i>Feet</i>			<i>Feet</i>	
Columbia, Va.....	18	12	12	26.4	12.
		17	19	28.8	17.
Richmond, Va.....	10	12	13	16.6	13.
		18	19	17.0	18.
Roanoke River:					
Randolph, Va.....	21	12	15	31.6	13.
		17	20	31.2	18.
Weldon, N. C.....	30	13	22	44.8	15.
Dan River:					
Danville, Va.....	8	12	13	12.7	12.
		17	18	10.2	18.
Clarksville, Va.....	12	13	14	15.2	14.
		19	20	14.5	19.
Neuse River: Smithfield, N. C.....	14	19	19	14.4	10.
Cape Fear River:					
Fayetteville, N. C.....	35	18	18	36.2	18.
Elizabethtown, N. C.....	22	18	21	27.4	19.
		23	26	26.7	25.

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC DRAINAGE—continued					
Peedee River:	<i>Feet</i>			<i>Feet</i>	
Cheraw, S. C.	27	17	20	35.3	18.
Mars Bluff, S. C.	17	15	29	22.7	23.
Santee River:					
Rimini, S. C.	12	13	(1)	30.4	21.
Ferguson, S. C.	12	14	(1)	20.6	22.
Catawba River:					
Mount Holly, N. C.	15	16	17	18.2	17.
Catawba, S. C.	12	15	18	26.0	17.
Wateree River:					
Camden, S. C.	24	17	20	35.0	18.
Malta, S. C.	16	20	20	16.4	20.
Congaree River: Columbia, S. C.	15	11	14	24.6	13.
		16	20	33.5	18.
Broad River: Blairs, S. C.	15	11	14	28.5	13.
		16	20	40.0	17.
Saluda River:					
Pelzer, S. C.	7	11	11	7.0	11.
		15	20	18.0	17.
Chappels, S. C.	14	11	22	29.1	17.
Savannah River:					
Calhoun Falls, S. C.	6	6	17	10.5	17.
Augusta, Ga.	32	17	19	40.4	17.
Broad River: Carlton, Ga.	11	15	17	20.0	16.
Altamaha River:					
Charlotte, Ga.	15	15	Sept. 1	26.2	22.
Doctortown, Ga.	10	22	29	11.0	23.
Everett City, Ga.	10	19	(1)	15.0	27-28.
Oconee River:					
Milledgeville, Ga.	22	11	12	33.4	11.
		15	18	41.1	16.
Dublin, Ga.	22	14	22	27.9	19.
Ocmulgee River:					
Macon, Ga.	18	11	11	20.7	11.
		15	16	23.0	16.
Hawkinsville, Ga.	29	19	19	29.1	19.
Abbeville, Ga.	11	15	28	16.8	17-18.
Lumber City, Ga.	15	18	28	20.3	22.
EAST GULF DRAINAGE					
Flint River: Albany, Ga.	20	17	19	20.1	17.
		21	22	20.5	22.
MISSISSIPPI DRAINAGE					
Ohio Basin					
Kanawha-New River:					
Radford, Va.	14	16	17	15.0	16.
Glenlyn, Va.	11	17	17	11.5	17.
French Broad River:					
Asheville, N. C.	4	15	19	12.0	16.
Marshall, N. C.	10	16	18	14.6	16.
Dandridge, Tenn.	12	17	17	17.2	17.
Big Pigeon River: Newport, Tenn.	6	16	16	12.4	16.
Nolichucky River: Embreeville, Tenn.	10	16	16	13.8	16.
Missouri Basin					
Smoky Hill River:					
Mentor, Kans.	22	3	9	25.3	4 and 8.
Solomon, Kans.	24	4	13	28.0	10.
Abilene, Kans.	22			24.3	
Solomon River:					
Beloit, Kans.	18	(2)	7	28.8	2.
Niles, Kans.	26			27.5	9.
Saline River: Tescott, Kans.	27			30.2	4 and 7.
Grand River: Chillicothe, Mo.	18	5	6	19.8	5.
Arkansas Basin					
Arkansas River: Webbers Falls, Okla.	23	6	6	23.6	6.
Neosho River: Fort Gibson, Okla.	22	5	6	24.5	6.

¹ Continued at end of month.

² Continued from last month.

MEAN LAKE LEVELS DURING AUGUST, 1928

BY UNITED STATES LAKE SURVEY

[Detroit, Mich., September 5, 1928]

The following data are reported in the Notice to Mariners of the above date:

Data	Lakes ¹			
	Superior	Michigan and Huron	Erie	Ontario
	Feet	Feet	Feet	Feet
Mean level during August, 1928:				
Above mean sea level at New York.....	603.02	580.50	572.59	246.64
Above or below—				
Mean stage of July, 1928.....	+0.15	+0.09	-0.12	-0.09
Mean stage of August, 1927.....	+0.26	+1.02	+0.58	+0.87
Average stage for August, last 10 years.....	+0.83	+0.44	+0.44	+0.74
Highest recorded August stage.....	-0.91	-3.01	-1.52	-1.62
Lowest recorded August stage.....	+2.00	+2.06	+1.51	+2.29
Average departure (since 1860) of the August level from the July level.....	+0.11	-0.55	-0.17	-0.30

¹ Lake St. Clair's level: In August, 1928, 575.51 feet.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, AUGUST, 1928

By J. B. KINCER

General summary.—During the first decade of August dry, warm weather throughout the Northwestern States was ideal for harvesting and threshing and these activities made rapid progress, while seasonal farm work, in general, advanced well practically everywhere west of the Appalachian Mountains. Except in the East and Southeast, very little rain occurred and larger and more numerous areas were needing moisture than at any time during the current growing season. The principal sections needing rain were the lower Ohio and adjoining parts of the Mississippi Valley, the more northwestern States, and the north-central and southern Great Plains. Considerable damage resulted to crops over rather extensive areas from New Jersey and eastern Pennsylvania southward where high winds and excessive rainfall blew down considerable corn, washed fields, flooded lowlands, and whipped much fruit from trees.

During the second decade the heavy to excessive rains in the same area, following those of the previous period, did heavy damage to crops. These conditions extended from the east Gulf coast northward to southeastern Pennsylvania and New Jersey, but along the immediate coast the weather was not so unfavorable and the rains did not extend a great distance inland. In the Northeast the warm, sunshiny weather was favorable and in the Ohio Valley showers were helpful, although some parts were still dry, but in western Texas and Oklahoma drought continued; other parts of the Southwest had beneficial rains. In the Northwest and generally west of the Rocky Mountains, the warm, mostly fair, and sunny weather made conditions ideal for harvest, and irrigated crops did well, although unirrigated were badly in need of moisture.

During the last decade moderate to rather generous rain in much of the Ohio Valley was beneficial for late crops, and showers in the Southwest were helpful. There was too much moisture in portions of the Atlantic Coast States which caused further damage to crops and dry, sunny weather was much needed. It continued dry in the west Gulf area and in the Pacific Northwest, but showers were of some benefit in the Northwestern States east of the Rocky Mountains.

Small grains.—During the first decade the warm, dry weather, except in the more eastern States, made un-

sually favorable conditions for harvesting and threshing in the late grain districts. Spring wheat harvest was well along in North Dakota and threshing was advancing in the southern portions of the belt; in north-central sections, where it had been too wet, fair, warm, sunshiny weather dried out much grain in shock. Many oats were threshed during the period and buckwheat did well, while the weather was favorable for rice and sorghum crops.

During the second decade unusually favorable weather in the late grain districts promoted good advance of harvesting and threshing. Most grains had been harvested in the spring wheat region and threshing was progressing. Considerable plowing was accomplished in the interior valleys, though this work was somewhat retarded by dry soil in the north-central Great Plains and in parts of the Ohio Valley. Threshing oats and barley progressed satisfactorily and flax did well; rice harvest was begun in Louisiana, while grain sorghums were favored in the Southwest.

At the close of the month wheat harvest had been practically completed and threshing was well along, though there was considerable interruption by rain in parts of the upper Mississippi Valley. Rains in the eastern Wheat Belt were beneficial in conditioning the soil for plowing, but only fair progress was reported from the western belt. Grain sorghums were mostly headed in the Southwest and flax was ripening rapidly in the northern Great Plains; conditions continued favorable for rice and harvest progressed well in Louisiana.

Corn.—During the first decade progress and condition of corn were mostly fair to excellent in the main producing sections, with much of the crop in roasting ears. Growth and condition were satisfactory in the Ohio Valley, and fair to excellent advance was made in Iowa, where about a third of the crop was in the roasting-ear stage. Corn made rapid advance in the Great Plains, but moisture was needed in parts; progress in the South varied from poor to good, while much was reported down in the Atlantic coast section. Rapid growth was indicated from the Great Lakes to the Rocky Mountains.

During the second decade the weather was not quite so favorable and progress varied from fair to excellent, with moisture needed in the Ohio Valley, where the crop was firing locally. In Iowa progress and condition were fair to very good, with nearly all in or past the roasting-ear stage. In parts of the Great Plains hot dry weather caused some damage; much was in hard roasting ears in Kansas, and the early crop had matured in Oklahoma. Late corn was poor in the drier areas of Texas, while in the East much was beaten down by heavy rain and wind; the crop was doing well from the Great Lakes to Montana.

During the last decade corn continued to make fair to very good progress, though there was some rather severe storm damage in localities of the upper Mississippi Valley. In the Ohio Valley rains were beneficial and in Missouri progress continued excellent. In Iowa advance was fair and the state of the crop ranged from roasting ears to well dented and nearly safe from frost. Drought in parts of the Great Plains seriously damaged corn; the crop showed deterioration in parts of Kansas and was affected to some extent in Oklahoma by dryness. There was some further damage by heavy rains in the Atlantic coast area, but otherwise good progress was noted.

Cotton.—During the first decade there was some damage to cotton in the eastern portions of the belt. In the Carolinas moderate damage was reported, but otherwise progress was fair to good, while in Georgia

heavy rains were harmful in the southeast, with open cotton whipped out and shedding increasing; picking made slow advance. In the central part of the belt progress was fair to very good, while in Louisiana advance was poor, due to shedding; in Arkansas it was very good, as the warm, dry weather was favorable. In Oklahoma progress was very good and the general condition ranged from fair to very good. In Texas progress was mostly satisfactory, but condition was poor in the drier lower coast and southwest; elsewhere plants were fruiting fairly well and picking made good advance in the south.

During the second decade considerable damage resulted from the storm in the Carolinas and Georgia, and the continued wetness was favorable for weevil activity. In the central part of the belt progress varied widely, ranging from deterioration to good, with shedding reported locally. In Louisiana cotton deteriorated badly in places, but in Arkansas progress was very good and plants were blooming and bolls forming rapidly in most parts. In Oklahoma warmth and sunshine were favorable, though considerable shedding was noted and the general condition was spotted. In Texas advance was also spotted, ranging from poor to very good; the condition of the crop was poor in the drier sections and fair to good elsewhere.

During the last decade less rainfall and moderately high temperatures gave some improvement in the Southeast, especially in Georgia, where progress was fair, but condition still poor to only fair, with continued shedding.

In the Carolinas growth was mostly fair, while in the central belt advance varied from poor to very good, with continued complaints of shedding. Opening was rapid in Louisiana, while in Arkansas progress was good in the north, but the crop deteriorated or made only fair advance in the south. In Oklahoma progress was rather poor, with plants fruiting only fairly well and much shedding. In Texas advance was spotted, ranging from poor to very good; hot dry weather in much of the south and sections of the central area caused considerable shedding and premature opening.

Miscellaneous crops.—Pastures and meadows were mostly good in practically all sections east of the Mississippi River, although they needed rain in parts of the Ohio Valley toward the close of the month. Moisture was needed in some parts of the Great Plains area, but in the more northern sections and in the upper Rocky Mountain region they were good to excellent. Ranges were generally dry in most sections west of the divide, but livestock held up well.

Except for some local complaints of blight and dryness, potatoes did well generally. Truck suffered from too much moisture in the Atlantic Coast States, but good advance was made generally, except that unirrigated crops needed rain in the West. Tobacco was favored generally and sugar cane made excellent advance. Citrus fruits were damaged in Florida by the storm, but were doing well elsewhere, while deciduous fruits made satisfactory progress.

WEATHER ON THE ATLANTIC AND PACIFIC OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

The weather over the North Atlantic during August presented few unusual features over the extratropical regions where approximately normal conditions prevailed.

There were two tropical disturbances during the month; the first was in the vicinity of Turks Island on the morning of the 5th and following the usual northwesterly path, struck the southeast coast of Florida on the 7th. On the 5th and 6th this disturbance was of a comparatively moderate nature, but on the 7th winds of hurricane force were reported by vessels near the center. The disturbance continued in its northwestward course until near the thirtieth parallel and eighty-third meridian on the 9th, when it began to recurve, and moving over the land, passed out to sea near the Virginia Capes on the morning of the 12th, with moderate to strong gales along the coast between Hatteras and New York.

The second disturbance was central near Jamaica on the 11th, and on that day strong easterly gales were encountered in the northerly quadrants as shown on Chart XII, and also by the report from the American S. S. *Bogota* in table. This disturbance decreased in intensity as it moved in a north-northwesterly direction, and was accompanied by comparatively moderate winds on the three succeeding days. On the 13th the center was off the southwest coast of Florida and on the 14th near Apalachicola. From this point it began to recurve slightly toward the east and gradually filled in as it moved over the land.

Charts VIII to XIII cover the period from the 7th to 12th inclusive, and it will be noticed that observations were being made in extreme northern waters, in the vicinity of Greenland. These reports were taken on board the U. S. Coast Guard cutter *Marion*, in command of Lieut. Commander E. H. Smith, engaged in making an investigation of the ice conditions in that region.

Fog was reported on 23 days in the waters adjacent to the American coast, between the fortieth and forty-fifth parallels; from 9 to 10 days over the Grand Banks, and from 1 to 3 days over the middle section of the steamer lanes.

TABLE 1.—Averages, departures, and extremes of atmospheric pressure at sea level, 8 a. m. (seventy-fifth meridian), North Atlantic Ocean, August, 1928

Stations	Average pressure	Departure ¹	Highest	Date	Lowest	Date
	Inches	Inch	Inches		Inches	
Julianehaab, Greenland	29.89	(?)	30.38	24th	29.32	31st.
Belle Isle, Newfoundland	29.94	+0.05	30.42	24th	29.24	31st.
Halifax, Nova Scotia	30.06	+0.05	30.35	26th	29.78	31st.
Nantucket	30.04	+0.04	30.30	27th	29.68	19th.
Hatteras	30.07	+0.03	30.24	27th	29.84	12th. ³
Key West	30.00	+0.02	30.08	2d	29.82	13th.
New Orleans	30.02	+0.05	30.10	1st ¹	29.82	10th.
Cape Gracias, Nicaragua	29.90	0.00	29.96	11th	29.86	15th. ³
Turks Island	30.05	+0.05	30.10	2d ¹	29.96	5th.
Bermuda	30.17	+0.08	30.30	1st	30.04	15th. ³
Horta, Azores	30.15	-0.05	30.32	20th	29.82	29th.
Lerwick, Shetland Islands	29.82	+0.02	30.19	2d ¹	29.35	8th.
Valencia, Ireland	29.86	-0.06	30.24	16th	29.41	12th.
London	29.96	-0.02	30.22	31st	29.68	12th.

¹ From normals shown on Hydrographic Office Pilot Charts, based on observations at Greenwich mean noon, or 7 a. m. seventy-fifth meridian.

² No normal available.

³ And on other dates.

From the 1st to 4th Newfoundland was covered by an area of low pressure, although moderate weather prevailed in that vicinity as well as over the entire ocean. From the 5th to 8th a disturbance of limited extent was over the eastern section of the steamer lanes, while favorable conditions prevailed elsewhere, with the exception of the tropical disturbance previously referred to.

Charts XII and XIII show the conditions on the 11th and 12th with a well-developed Low about 10° west of the Azores on the former date, and one off the European coast on the latter. The European Low remained nearly stationary during the next 24 hours, and then moved northeastward, decreasing in intensity.

On the 14th St. Johns, Newfoundland, was about 5° west of a Low that moved steadily eastward and on the 21st was over the North Sea. This Low was accompanied by moderate weather, except on the 17th and 18th, when westerly gales of force 7 and 8 prevailed over the middle section of the steamer lanes.

From the 22d to 24th the region between the forty-fifth and fifty-fifth parallels and twentieth and thirtieth meridians was swept by a comparatively severe disturbance, with winds of force 9 and 10 at time of observation. On the 22d the Coast Guard cutter *Marion* encountered a moderate gale in extreme northern waters, as shown by report in table.

From the 25th to 28th there ensued another period of favorable weather over the ocean as a whole, although during the greater part of that period an area of low pressure was over the British Isles.

On the 29th the Azores was surrounded by a well defined disturbance, the storm area extending from the twenty-fifth to thirty-third meridian. This Low apparently filled in as rapidly as it formed, as on the 30th and 31st moderate weather again prevailed over practically the entire ocean.

NOTE.—Honduran S. S. *Choluteca*, Capt. N. Christiansen, Observer; Th. Thorsen, second officer:

At 6 a. m. on August 16, in 16° 14' N., 87° 48' W., there was observed a very large waterspout being formed about 1 mile astern of the ship. It was seen for 13 minutes when it suddenly parted in the middle and disappeared. It had an even thickness from cloud to sea level and was traveling in an east-northeasterly direction with about a 5-mile speed and whirling the sea in a counter clockwise direction.

The spout was estimated to be about 2,000 feet high with a diameter of about 150 feet. Weather was overcast with heavy nimbus clouds hanging over the spout, variable light breeze, barometer 29.82, temperature of air 81°, rain drizzle on ship (in front of spout) but heavy downpour seen behind track.

OCEAN GALES AND STORMS, AUGUST, 1928

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN													
Sixola, Am. S. S.	Kingston, Jamaica.	New York	22 56 N.	74 23 W.	Aug. 5.	4p., 5.	Aug. 5.	29.78	N.	W., 8.	SE.	W., 8.	NW.-SE.
Mississippi, Br. M. S.	New York	Antwerp	45 00 N.	34 56 W.	5.	3a., 5.	6.	29.77	NW.	NW., 7.	WNW.	—, 8.	Steady.
München, Ger. S. S.	Galway, Ireland.	New York	52 30 N.	21 13 W.	5.	6a., 6.	8.	29.90	S.	SW., 8.	WSW.	W., 9.	SW.-W.
Creole, Am. S. S.	New York	New Orleans	28 49 N.	78 30 W.	6.	Mdt., 6.	7.	29.51	NE.	NE., 3.	SW.	NW., 11.	NE.-N.-WSW.
Gulf of Mexico, Am. S. S.	Port Arthur.	New York	26 05 N.	79 48 W.	7.	Mdt., 7.	8.	29.42	WNW.	WNW., 10.	SE.	SW., 12.	NW.-W.-S.-SE.
Lempira, Am. S. S.	Puerto Cortez.	do.	26 00 N.	79 50 W.	7.	3a., 7.	7.	28.68	N.	W., 3.	SE.	—, 12.	W.-NE.-S.
Bogota, Am. S. S.	West Indies.	do.	19 23 N.	75 02 W.	11.	7a., 11.	11.	29.88	E.	E., 9.	E.	F., 11.	Steady.
Motorcarline, Belg. M. S.	Baton Rouge	Antwerp	38 07 N.	35 45 W.	11.	7a., 11.	12.	29.97	SE.	SE., 7.	N.	—, 8.	—.
El Almirante, Am. S. S.	New York	New Orleans	24 39 N.	80 58 W.	11.	7p., 12.	13.	29.72	SSW.	SE., 9.	WNW.	S., 12.	SE.-S.-NW.
Cananova, Am. S. S.	do.	West Indies.	38 55 N.	74 08 W.	12.	4p., 12.	12.	29.58	NE.	NE., 9.	NE.	NE., 9.	Steady.
Galtymore, Br. S. S.	Nordenham.	Norfolk	58 59 N.	14 20 W.	12.	Mdt., 12.	13.	29.38	E.	NE., 9.	N.	NNE, 10.	Do.
San Gil, Br. S. S.	Boston	Habana	24 39 N.	80 45 W.	12.	3a., 13.	13.	29.78	SE.	SE., 9.	S.	—, 9.	SE.-S.
Careno, Am. S. S.	Casablanca	New York	41 32 N.	43 51 W.	13.	6a., 13.	14.	29.72	S.	S., 7.	W.	—, 8.	—.
Steelmaker, Am. S. S.	Canal Zone	do.	18 00 N.	75 30 W.	14.	10p., 14.	14.	29.99	NE.	NE., 5.	NE.	NE., 6.	NE.-ENE.
Berlin, Ger. S. S.	Bremerhaven	do.	47 38 N.	29 00 W.	15.	—, 15.	16.	29.87	SSE.	SSE., 8.	SSE.	—, 10.	—.
Leviathan, Am. S. S.	Southampton	do.	48 12 N.	25 56 W.	16.	11a., 16.	16.	29.79	S.	S., 8.	SSW.	—, 8.	S.-SSW.
Galtymore, Br. S. S.	Nordenham.	Norfolk	52 30 N.	40 35 W.	17.	8a., 17.	18.	29.17	W.	W., 9.	WNW.	NW., 10.	SW.-W.-WNW.
Hog Island, Am. S. S.	Gibraltar	Boston	39 38 N.	66 33 W.	18.	—, 18.	18.	29.82	NW.	N., —.	N.	N., 10.	NW.-N.
Nieuw Amsterdam, Du. S. S.	Rotterdam	New York	43 12 N.	43 30 W.	20.	1a., 21.	21.	29.83	SW.	—, 8.	WNW.	SW., 8.	SW.-W.-NW.
Marion, U. S. M. S.	Greenland	Vineyard Haven.	61 47 N.	64 10 W.	22.	6a., 22.	23.	29.28	—.	E., 7.	—.	ESE., 8.	ESE.-S.
Balsam, Am. S. S.	Manchester	New York	51 50 N.	24 45 W.	21.	5a., 22.	24.	29.04	WSW.	WSW., 10.	NW.	WSW., 10.	WSW.-NW.
Belleplaine, Am. S. S.	Rotterdam	do.	50 33 N.	23 34 W.	21.	2a., 23.	24.	29.40	WSW.	W., 9.	N.	W., 9.	WSW.-NW.
Marion, U. S. M. S.	Greenland	Vineyard Haven.	61 11 N.	48 22 W.	29.	7p., 29.	30.	29.30	—.	E., 8.	—.	SE., 8.	E.-SE.
Lucellum, Br. S. S.	Falmouth	Canal Zone	38 50 N.	30 20 W.	29.	Noon, 29.	30.	29.65	SSE.	W., —.	NNW.	WNW., 10.	SSE.-W.-NNW.
Motorcarline, Belg. M. S.	Antwerp	Baton Rouge	40 47 N.	27 20 W.	29.	10 p., 29.	30.	29.88	S.	S., 7.	NW.	—, 11.	—.
NORTH PACIFIC OCEAN													
Akibasan Maru, Jap. S. S.	Vancouver	Yokohama	52 03 N.	158 16 W.	July 31	Noon, 31.	1.	29.73	SSE.	SW., 9.	W.	SSW., 9.	2 points.
Silveray, Br. M. S.	Manila	San Francisco	32 25 N.	139 00 E.	Aug. 2	8a., 4.	4.	29.13	N.	ENE., 11.	ENE.	ENE., 12.	N.-SE.
Kaga Maru, Jap. S. S.	Victoria	Yokohama	51 45 N.	165 03 W.	3.	1a., 3.	4.	29.59	SE.	SW., 8.	N.	SW., 8.	2 points.
Hampstead, Br. S. S.	Comox, B. C.	Karatsu	52 16 N.	136 19 W.	8.	4a., 9.	9.	29.44	S.	S., 8.	S.	SSW., 9.	S.-SSW.
Africa Maru, Jap. S. S.	Yokohama	Yokohama	40 00 N.	150 00 E.	11.	4p., 11.	12.	29.38	ENE.	ENE., 7.	SE.	SE., 8.	ENE.-SE.
Chief Capitano, Br. S. S.	Vancouver	Yokohama	45 52 N.	162 24 E.	12.	7p., 13.	13.	29.51	SE.	S., 4.	S.	SE., 9.	SE.-SSW.
Bellingham, Am. S. S.	Hong Kong.	San Francisco	29 29 N.	132 57 E.	16.	6p., 17.	18.	29.26	N.	SSW., 10.	W.	SSW., 10.	SW.-SSW.
Pres. Taft, Am. S. S.	San Francisco	Yokohama	34 56 N.	149 08 E.	18.	—, 18.	19.	29.36	ESE.	NNE., 7.	N.	ENE., 8.	—.
Erie Maru, Jap. S. S.	Milke	California	49 12 N.	157 45 W.	27.	4a., 28.	29.	29.79	SW.	S., 8.	SW.	S., 8.	—.

MEXICAN HURRICANE REPORTS

<i>Florence Luckenbach</i> , Am. S. S.	San Pedro	New Orleans	15 45 N.	99 05 W.	Aug. 6.	2p., 6.	Aug. 7.	29.72	ENE.	ENE., 8.	E.	ENE., 8.	1 point.
<i>La Crescenta</i> , Br. S. S.	San Francisco	Balboa	16 04 N.	100 05 W.	6.	3p., 6.	7.	29.84	ESE.	ESE., 8.	SE.	ESE., 9.	ESE-SE.
<i>Sylvan Arrow</i> , Am. S. S.	San Pedro	do.	16 58 N.	101 09 W.	7.	1a., 7.	7.	29.84	ESE.	ESE., —.	ESE.	ESE., 8.	Steady.
<i>Ipswich</i> , Am. S. S.	Los Angeles	Panama Canal.	20 40 N.	107 05 W.	8.	6p., 8.	8.	29.71	NE.	ESE., 9.	SSE.	SE., 10.	NE-SSE.
<i>Kenowis</i> , Am. S. S.	San Francisco	Balboa	19 08 N.	105 00 W.	8.	Noon, 8.	8.	—.	ESE.	—.	E.	—, 10.	ESE-E.
<i>Justin</i> , Ger. S. S.	San Pedro	Hamburg	22 35 N.	110 10 W.	9.	7p., 9.	9.	29.12	NNW.	—, 12.	—.	—, 12.	—.
<i>Canad. Importer</i> , Br. S. S.	Victoria	Panama Canal	22 59 N.	110 18 W.	9.	Mdt., 9.	10.	29.40	N.	SE., 10.	SW.	SE., 10.	NE-E-SE.
<i>Solana</i> , Am. S. S.	San Pedro	Balboa	23 14 N.	111 27 W.	10.	8a., 10.	10.	29.37	NNE.	NW., 10.	SSW.	N., 10.	N-NW-SW.
<i>Henry D. Whiton</i> , Am. S. S.	Columbia River.	New York	23 37 N.	112 15 W.	10.	9a., 10.	10.	29.72	NNE.	NW., 10.	SW.	NW., 10.	—.
<i>Suspearco</i> , Am. S. S.	Los Angeles	Balboa	24 10 N.	112 05 W.	10.	4p., 10.	10.	29.42	NE.	NE., 10.	SE.	ENE., 12.	NE-E-SE.
<i>K. R. Kingsbury</i> , Am. S. S.	San Francisco	do.	23 10 N.	111 05 W.	10.	6a., 10.	10.	29.08	NE.	Calm.	SSW.	NE., 12.	NE-O-SW.
SOUTH PACIFIC OCEAN													
<i>Golden Forest</i> , Am. S. S.	Dunedin	Honolulu	Cook Straits.	—.	15.	8p., 15.	16.	29.20	SSW.	SSW., 6.	—.	N., 10.	—.

NORTH PACIFIC OCEAN

By WILLIS E. HURD

The anticyclone of the eastern part of the ocean in middle latitudes continued well developed in August, as in July. Normally its greatest strength occurs in mid-summer, and the same fact holds true this year so far as is indicated by observations up to the present time.

The Aleutian Low exists on the average this month as a shallow area of diminished pressure over the northern part of Bering Sea and the adjacent continental neighborhoods, but during August, 1928, it showed as a depression along the Alaskan Peninsula and adjoining southern and eastern waters, the center being near Kodiak. It developed considerable activity on several days, causing fresh gales along its lower quadrants.

The following table gives barometric data for several island and coast stations in west longitudes:

TABLE 1.—Averages, departures, and extremes of atmospheric pressure at sea level at indicated hours, North Pacific Ocean, August, 1928

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	Inch	Inches		Inches	
Dutch Harbor ¹	29.84	-0.06	30.42	14th	29.14	28th.
St. Paul ¹	29.88	+0.12	30.44	14th	29.34	28th.
Kodiak ¹	29.77	-0.08	30.20	14th	29.08	5th.
Midway Island ¹	30.11	+0.02	30.18	5th	30.04	9th.
Honolulu ¹	30.04	+0.03	30.13	3d	29.92	28th.
Juneau ¹	30.06	+0.04	30.42	23d	29.43	5th.
Tatoosh Island ¹	30.09	+0.04	30.23	22d	29.79	25th.
San Francisco ¹	30.00	+0.06	30.09	28th	29.81	25th.
San Diego ¹	29.92	+0.03	30.04	16th	29.79	20th.

¹ P. m. observations only.

² For 30 days.

³ For 29 days.

⁴ A. m. and p. m. observations.

⁵ Corrected to 24-hour mean.

⁶ Also on the 6th.

Following upon the very quiet month of July, in northern waters of the Pacific, August set in with considerable increase in storminess, fresh to strong gales being encountered at several times and places along the upper sailing routes.

Tropical disturbances were almost as numerous as extratropical, and much more violent. Reports on the July and August typhoons of the Far East, by the Rev. José Coronas, S. J., chief of the meteorological division of the Philippine Weather Bureau, are subjoined. In his July report, in which a tropical cyclone is stated as lost to observation south of Japan on August 1, it should be further remarked of this intense storm that, according to the Tokyo weather charts, it remained very nearly in its position of the 1st until the 5th, when it moved with greatly decreased energy into the Japan Sea. The British motor ship *Silveray* was heavily involved in the typhoon during the late hours of the 2d and through the 3d and 4th. At noon observation of the 3d, in 31° 15' N., 137° 30' E., and of the 4th, in 32° 28' N., 139° 10' E., wind forces of 11 from N. and ENE., respectively, were experienced, with hurricane velocities at other times, and accompanying low pressures.

Hurricane of August 6-11 off the Mexican coast.—A tropical cyclone of great fury raged over the entrance to the Gulf of California and up the lower west coast of the adjoining peninsula on the 9th and 10th, and with lesser violence in the coastal waters to the southward of Cape Corrientes on the 6th to 8th. High winds were reported at shore stations during the passage of the storm, and a strong southwesterly gale was blowing at La Paz as late as the morning observation of the 11th.

This cyclone may have originated as early as the 3d in latitude 8°-9° N., longitude 85°-87° W., where unsettled conditions, with strong shifting winds, were encountered by the American motorship *Unicoi*. However, the earliest report of gales comes from the southbound American steamer *Florence Luckenbach*, which ran into a strong wind at noon of the 6th. At 2 o'clock, in 15° 45' N., 99° 05' W., the wind had increased to a gale of force 8 from east-northeast, barometer depressed to 29.72 inches. On the following morning the British steamer *La Crescenta* encountered an east-southeast gale, force 8-9, in nearly the same position. On the 8th the gale-swept region extended, so far as observations show, from a little below Manzanillo to a little above Cape Corrientes. The storm had increased in energy, with whole southeasterly gales and lower pressures. Up to this time the cyclone had been running outside of the usual steamship routes, which closely hug the coast. Early on the 9th, however, as it began moving across the outer waters of the Gulf of California, vessels became involved in other quadrants of the storm and in or near its center. Late on the night of the 8th the American steamer *William A. McKenney*, southbound, ran into a strong easterly gale in 21° 28' N., 108° 21' W., according to press accounts. The wind rapidly increased in violence, and shortly after midnight was blowing an easterly hurricane, barometer down to 28.50 inches. About 1 a. m. the vessel was so battered by terrific seas that much damage was done to cargo and upper works, and 14 members of the deck crew of 20, in attempting repairs, were washed overboard and drowned. At 2 a. m. of the 9th the steamer passed through the center of the hurricane, and at 4 a. m. moderating weather allowed her to make a search for the missing members of her crew, then shortly to proceed on her voyage.

At near 6 a. m. of the 10th the American steamer *K. R. Kingsbury*, Capt. D. W. Thomsen, San Francisco toward Balboa, ran into the "eye" of the hurricane in 23° 10' N., 111° 05' W. The storm report made to the Weather Bureau by the observer, Mr. George Barkley, second officer, is of such interest that it may be quoted herewith in part:

At 2:30 a. m. rain commenced to fall, at first in showers, and later steadily and heavily, so that the sea was obscured.

The wind reached hurricane force at 5 a. m., with a high NE. sea and heavy rain. At 5:45 the wind abruptly dropped to a calm as the ship reached the center of the hurricane. The barometer had now reached its minimum height of 29.08. For a half hour the vessel steamed in a calm with a slight confused sea, and then at 6:15 the wind suddenly came again from the SW. with hurricane force. At once a high southwesterly sea appeared. The wind did not long continue at its maximum force in this semicircle, falling in strength to a strong gale at 7 a. m. The glass was now rising fast, but with a diminishing rate. Rain continued to fall in the "eye" and after the vessel entered the right semicircle.

The vessel passed directly through the center of the depression with the hurricane traveling almost north in its track. From observations of the weather and estimates of the ship's speed a rough approximation of the extent of this disturbance can be made. If the hurricane is allowed a rate of progress of 10 miles an hour, the center or "eye" was 10 miles in diameter. On each side of this was a belt of hurricane force winds, 15 miles in width on the foreside and 10 miles in width behind. Winds of gale force and stronger were felt in a belt of 75 miles width on each side of the zone of hurricane winds. The diameter of the storm can be estimated as approximately 190 miles.

At the time that the wind blew a hurricane atmospheric pressure had changed so rapidly that the ears of several observers were uncomfortable. At daylight in the morning a number of butterflies were found beaten to the deck, evidence that the strong winds had extended to the land.

During the afternoon of the 10th the center evidently passed to the northwestward of Cape San Lucas, and on

the 11th the storm apparently died out in the highlands of the southern half of Lower California.

At Honolulu light trades blew 99 per cent of the time, with prevailing direction from the east. The maximum velocity for the month was 22 miles from the northeast on the 23d.

Fog was about one-half as frequent along the western half of the northern sailing routes as in July, the percentage of occurrence falling to 20 to 30, or slightly more in some localities. Fog lessened in west longitudes, except along the American coast between latitudes 25° and 40° N., where it was reported on 7 to 10 days in most 5° squares. At St. Paul, in Bering Sea, there is record of fog forming on 13 days in August.

Waterspout.—The unusual occurrence for the region of a waterspout in 33° 55' N., 143° 56' W., is to be noted. It was observed by the American steamer *Manini* at 2 p. m. of the 19th and lasted for 15 minutes, traveling northeast for a distance of about 5 miles, during the prevalence of a southeast wind of force 4. Heavy sheets of rain fell in its immediate vicinity. At the end the spout sundered, the lower half falling to the sea, the upper rising to the cloud.

INDIAN OCEAN

By WILLIS E. HURD

Southwest monsoon.—Very strong monsoon currents were reported from a section of the southwestern part of the Arabian Sea on the 3d to 5th and 29th to 31st of August. On the earlier dates the British steamer *City of Chester*, in latitudes 9° to 13° N., longitudes 59° to 55° E., encountered daily fierce southwesterly squalls of forces 9 to 10. At the end of the month the American motor ship *William Penn*, in nearly the same position, reported high seas, with monsoon winds of forces 8 to 9.

Volcanic dust.—The British steamer *Emlynian*, H. E. Maber, captain and observer, sends the following report of volcanic dust observed in the South Indian Ocean:

August 5, 4:30 a. m., 12 miles NNW. of Toro Besi Point, Flores, encountered thick haze which an hour later became so dense as to enable us to see no farther than bows of ship. The cause was volcanic dust and sulphurous smoke blown off the land. The wind shifted to east about 7 a. m. and the sky began to lighten, but although an hour after sunrise at this time it was still quite dark. The ship was now completely covered from masts to water line with a thick coat of white powder resembling fuller's earth and an inch or more deep. At 7:45 daylight appeared, with small rain and general clearing of atmosphere, and at 10 a. m. sun shining with clear horizon to N. and E., and greenish appearance of sea.

TYPHOONS IN THE FAR EAST IN JULY AND AUGUST, 1928

By REV. JOSÉ CORONAS, S. J.

[Weather Bureau, Manila, P. I.]

July, 1928.—The first typhoon which has visited the Philippines during this year was probably formed on July 7 about 200 miles to the WSW. of Guam. Yet the first part of its track is rather indefinite until 2 p. m. of the 10th, when its center was clearly shown by our weather map to the east of southern Luzon in about 130° longitude E. and 14° latitude N. From that time the typhoon moved to WNW. and NW. by W. until it reached northern Luzon shortly after midnight of the 11th. The center of the storm passed across the Provinces of Cagayan and Ilocos with a due W. direction. The barometric minimum recorded in our stations was that of Tuguegarao 737.25 mm. at 4:30 a. m. of the 12th.

Once in the China Sea the typhoon moved to NNW. for several hours, and then to WNW. and W. from 2 p. m. of the 13th until it reached the northernmost part of Indo-China in the early morning of the 16th.

The center passed very close to the south of Pratas at about 2 a. m. of July 14, with a barometric minimum of 738.9 mm. and hurricane winds from the easterly quadrants.

The approximate positions of the center at 6 a. m. and 2 p. m. of July 11 to 14 were as follows:

July 11, 6 a. m.,	126° 25' longitude E.,	15° 05' latitude N.
July 11, 2 p. m.,	125° 00' longitude E.,	16° 00' latitude N.
July 12, 6 a. m.,	121° 10' longitude E.,	17° 55' latitude N.
July 12, 2 p. m.,	120° 15' longitude E.,	17° 55' latitude N.
July 13, 6 a. m.,	119° 00' longitude E.,	19° 00' latitude N.
July 13, 2 p. m.,	118° 10' longitude E.,	19° 50' latitude N.
July 14, 6 a. m.,	115° 20' longitude E.,	20° 50' latitude N.
July 14, 2 p. m.,	113° 45' longitude E.,	21° 05' latitude N.

The second typhoon of this month appeared as developing on the 18th in the China Sea, about 100 miles to the west of central Luzon near 118° longitude E. and 15° latitude N. It moved WNW. for a short time, and then due W. until it reached Indo-China in the early morning of the 21st. The center was over the Paracels at 6 a. m. of the 20th.

The third typhoon followed a very abnormal track. It was formed about 300 miles to the north of Yap on the 20th to 22d near 138° longitude E. and 14° latitude N. It moved NE. on the 23d, ENE. in the morning of the 24th, and E. in the afternoon of the same day and during the 25th. On the 26th it recurved to the N. and WNW. in the neighborhood of 147° longitude E., between 17° and 18° latitude N. The WNW. direction was kept until the morning of the 28th, when the typhoon recurved again to the NE. near 135° longitude E. and 22° latitude N. From 12 noon of the 29th until the 31st the direction of the track was almost due N.

The steamer *President Harrison* was near the coast of southeastern Japan when this typhoon was just between the Bonins and Japan. She reported a barometric minimum of 732.3 mm. at 12 midnight of July 31, and a whole gale from the east quadrants on the 31st, and from the north quadrants on August 1.

On August 1 the typhoon seems to have moved eastward, but we have no means to follow its track after that day.

The approximate positions of the typhoon at 6 a. m. of July 24 to 31 were as follows:

July 24, 6 a. m.,	140° 50' longitude E.,	16° 15' latitude N.
July 25, 6 a. m.,	144° 45' longitude E.,	17° 10' latitude N.
July 26, 6 a. m.,	145° 45' longitude E.,	17° 20' latitude N.
July 27, 6 a. m.,	143° 20' longitude E.,	19° 15' latitude N.
July 28, 6 a. m.,	134° 45' longitude E.,	22° 00' latitude N.
July 29, 6 a. m.,	138° 50' longitude E.,	26° 25' latitude N.
July 30, 6 a. m.,	140° 00' longitude E.,	29° 45' latitude N.
July 31, 6 a. m.,	140° 00' longitude E.,	31° 45' latitude N.

The fourth typhoon was of a short duration. It was formed on the 22d near 144° longitude E. and 20° or 21° latitude N. and moved northwestward to the south and southwest of the Bonins, filling up in the afternoon of the 24th near 137° longitude E. and 27° or 28° latitude N.

August, 1928.—The first typhoon of August appeared on our weather maps of the 8th far to the southwest of the Bonins near 135° longitude E. and 22° latitude N. It moved ENE., passing to the south of the Bonins in the afternoon of the 9th. From the 10th to the 13th the typhoon moved to the N. about 500 miles to the east of the Bonins and of central Japan. The steamer *Empress of Russia* was well under the influence of this typhoon on August 12 in about 145° longitude E. and

39° latitude N. She reported a gale from the north and a barometric reading 744.5 mm. at 4 a. m. of that day.

The second typhoon made its appearance as a continental depression over eastern China to the north of Hong Kong on August 8 and 9. It developed into a real typhoon in the Formosa Channel, and still more to the east of Formosa. It moved ENE. and NE. across the Loochoos on the 11th to 13th; then it remained almost stationary to the east of the northern Loochoos on the 14th to 16th; it moved northward on the 17th and the morning of the 18th; and finally it recurved to the east at noon of the 18th near to the south of Japan. On the 20th it was moving ENE. to the east of Japan.

The approximate positions of the center at 6 a. m. of August 10 to 20 were as follows:

August 10, 6 a. m.,	117° 20' longitude E.,	24° 25' latitude N.
August 11, 6 a. m.,	123° 00' longitude E.,	24° 40' latitude N.
August 12, 6 a. m.,	126° 15' longitude E.,	25° 15' latitude N.
August 13, 6 a. m.,	129° 35' longitude E.,	27° 10' latitude N.
August 14, 6 a. m.,		
August 15, 6 a. m.,	131° 15' longitude E.,	27° 50' latitude N.
August 16, 6 a. m.,		
August 17, 6 a. m.,	131° 30' longitude E.,	28° 45' latitude N.
August 18, 6 a. m.,	132° 10' longitude E.,	31° 00' latitude N.
August 19, 6 a. m.,	134° 25' longitude E.,	32° 00' latitude N.
August 20, 6 a. m.,	140° 00' longitude E.,	32° 55' latitude N.

The third typhoon is the only one that visited the Philippines during this month. It was formed on the

20th to 21st to the southwest of Guam near 142° longitude E., between 11° and 12° latitude N. It moved WNW. until 2 p. m. of the 23d, when it took a westerly direction, traversing northern Luzon on the 24th in the form of a shallow depression. In the China Sea it developed into a severe typhoon which crossed the Paracels on the 25th and 26th.

The fourth typhoon was noticed on our weather maps on the 22d as forming to the south of Guam near 145° longitude E. and 10° latitude N. It moved NW. by W. until 2 p. m. of the 24th, and W. from that time until 6 a. m. of the 25th; then it recurved to the north, reaching southwestern Japan during the night of the 29th to 30th. It recurved NNE. in the Sea of Japan in the afternoon of the 30th.

The approximate positions of the center at 6 a. m. of August 23 to 31 were as follows:

August 23, 6 a. m.,	141° 40' longitude E.,	12° 30' latitude N.
August 24, 6 a. m.,	136° 45' longitude E.,	16° 00' latitude N.
August 25, 6 a. m.,	130° 35' longitude E.,	17° 25' latitude N.
August 26, 6 a. m.,	129° 10' longitude E.,	19° 00' latitude N.
August 27, 6 a. m.,	129° 20' longitude E.,	20° 55' latitude N.
August 28, 6 a. m.,	131° 00' longitude E.,	26° 00' latitude N.
August 29, 6 a. m.,	131° 10' longitude E.,	27° 50' latitude N.
August 30, 6 a. m.,	131° 50' longitude E.,	32° 50' latitude N.
August 31, 6 a. m.,	135° 00' longitude E.,	40° 00' latitude N.

July 1928.—The first typhoon which has visited the Philippines during this year was probably formed on July 7 about 200 miles to the WSW of Guam. The first part of its track is rather indistinct until 2 p. m. of the 10th, when the center was clearly shown by our weather map to the east of southern Luzon in about 140° longitude E. and 14° latitude N. From that time the typhoon moved to WNW. and N. by W. until it reached northern Luzon shortly after midnight of the 11th. The course of the storm passed across the Province of Cayan and Ilocos with a line W. through the Philippine Islands. The typhoon was at its most powerful at 1:30 a. m. of the 12th, when it was reported from a section of the southwestern part of the Arabian Sea on the 11th and 12th to the 13th. The center was at 13° N. latitude and 130° E. longitude. It encountered daily heavy easterly squalls from 9 to 10. At the end of the month the typhoon moved ship WNW. in heavy easterly squalls. It reported high seas with monsoon winds of force 8 to 9. The British steamer *Albatross* on the 11th. Major, captain and observer, sends the following report of volcanic dust observed in the South Indian Ocean. August 1, 1928. At 12 miles WNW of Port Blair, India, encountered thick haze which at 10 a. m. became so dense as to render it impossible to see further than 10 miles. The haze was volcanic dust and consisted of small particles of lava and ash. The dust was not completely cleared from the haze until 10 a. m. of the 2d, when it was replaced by a thick haze of volcanic dust. At 10 a. m. of the 2d, the dust was again observed. At 10 a. m. of the 3d, the dust was again observed. At 10 a. m. of the 4th, the dust was again observed. At 10 a. m. of the 5th, the dust was again observed. At 10 a. m. of the 6th, the dust was again observed. At 10 a. m. of the 7th, the dust was again observed. At 10 a. m. of the 8th, the dust was again observed. At 10 a. m. of the 9th, the dust was again observed. At 10 a. m. of the 10th, the dust was again observed. At 10 a. m. of the 11th, the dust was again observed. At 10 a. m. of the 12th, the dust was again observed. At 10 a. m. of the 13th, the dust was again observed. At 10 a. m. of the 14th, the dust was again observed. At 10 a. m. of the 15th, the dust was again observed. At 10 a. m. of the 16th, the dust was again observed. At 10 a. m. of the 17th, the dust was again observed. At 10 a. m. of the 18th, the dust was again observed. At 10 a. m. of the 19th, the dust was again observed. At 10 a. m. of the 20th, the dust was again observed. At 10 a. m. of the 21st, the dust was again observed. At 10 a. m. of the 22nd, the dust was again observed. At 10 a. m. of the 23rd, the dust was again observed. At 10 a. m. of the 24th, the dust was again observed. At 10 a. m. of the 25th, the dust was again observed. At 10 a. m. of the 26th, the dust was again observed. At 10 a. m. of the 27th, the dust was again observed. At 10 a. m. of the 28th, the dust was again observed. At 10 a. m. of the 29th, the dust was again observed. At 10 a. m. of the 30th, the dust was again observed. At 10 a. m. of the 31st, the dust was again observed.

TYPHOONS IN THE FAR EAST IN JULY AND AUGUST, 1928

The first typhoon of the season was reported from the Philippines on July 7. It was probably formed on July 7 about 200 miles to the WSW of Guam. The first part of its track is rather indistinct until 2 p. m. of the 10th, when the center was clearly shown by our weather map to the east of southern Luzon in about 140° longitude E. and 14° latitude N. From that time the typhoon moved to WNW. and N. by W. until it reached northern Luzon shortly after midnight of the 11th. The course of the storm passed across the Province of Cayan and Ilocos with a line W. through the Philippine Islands. The typhoon was at its most powerful at 1:30 a. m. of the 12th, when it was reported from a section of the southwestern part of the Arabian Sea on the 11th and 12th to the 13th. The center was at 13° N. latitude and 130° E. longitude. It encountered daily heavy easterly squalls from 9 to 10. At the end of the month the typhoon moved ship WNW. in heavy easterly squalls. It reported high seas with monsoon winds of force 8 to 9. The British steamer *Albatross* on the 11th. Major, captain and observer, sends the following report of volcanic dust observed in the South Indian Ocean. August 1, 1928. At 12 miles WNW of Port Blair, India, encountered thick haze which at 10 a. m. became so dense as to render it impossible to see further than 10 miles. The haze was volcanic dust and consisted of small particles of lava and ash. The dust was not completely cleared from the haze until 10 a. m. of the 2d, when it was replaced by a thick haze of volcanic dust. At 10 a. m. of the 2d, the dust was again observed. At 10 a. m. of the 3d, the dust was again observed. At 10 a. m. of the 4th, the dust was again observed. At 10 a. m. of the 5th, the dust was again observed. At 10 a. m. of the 6th, the dust was again observed. At 10 a. m. of the 7th, the dust was again observed. At 10 a. m. of the 8th, the dust was again observed. At 10 a. m. of the 9th, the dust was again observed. At 10 a. m. of the 10th, the dust was again observed. At 10 a. m. of the 11th, the dust was again observed. At 10 a. m. of the 12th, the dust was again observed. At 10 a. m. of the 13th, the dust was again observed. At 10 a. m. of the 14th, the dust was again observed. At 10 a. m. of the 15th, the dust was again observed. At 10 a. m. of the 16th, the dust was again observed. At 10 a. m. of the 17th, the dust was again observed. At 10 a. m. of the 18th, the dust was again observed. At 10 a. m. of the 19th, the dust was again observed. At 10 a. m. of the 20th, the dust was again observed. At 10 a. m. of the 21st, the dust was again observed. At 10 a. m. of the 22nd, the dust was again observed. At 10 a. m. of the 23rd, the dust was again observed. At 10 a. m. of the 24th, the dust was again observed. At 10 a. m. of the 25th, the dust was again observed. At 10 a. m. of the 26th, the dust was again observed. At 10 a. m. of the 27th, the dust was again observed. At 10 a. m. of the 28th, the dust was again observed. At 10 a. m. of the 29th, the dust was again observed. At 10 a. m. of the 30th, the dust was again observed. At 10 a. m. of the 31st, the dust was again observed.

CLIMATOLOGICAL TABLES¹

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, August, 1928

Section	Temperature							Precipitation						
	Section average	Departure from the normal	Monthly extremes					Section average	Departure from the normal	Greatest monthly		Least monthly		
			Station	Highest	Date	Station	Lowest			Date	Station	Amount	Station	Amount
	° F.	° F.		° F.			° F.		In.	In.		In.		In.
Alabama	80.9	+1.3	3 stations	100	24	Riverton	57	22	4.55	+0.01	Saint Bernard	9.20	Demopolis	0.92
Arizona	78.9	-0.6	Mohawk	117	9	Bright Angel	29	6	2.20	+0.07	Bisbee	7.50	2 stations	0.00
Arkansas	81.3	+1.6	Texarkana	105	28	Lurton	51	31	4.62	+0.93	Thornburg	10.57	Portland	0.73
California	71.7	0.0	2 stations	121	21	Helm Creek	22	24	0.01	-0.08	McCloud	0.35	209 stations	0.00
Colorado	63.8	-1.2	Eads	104	19	2 stations	20	21	1.31	-0.68	Savage Basin	4.45	Nast	0.10
Florida	81.4	0.0	5 stations	100	23	4 stations	66	23	9.82	+2.71	Monticello	22.19	Bonifay	2.68
Georgia	79.9	+0.5	3 stations	100	23	2 stations	56	22	9.99	+4.77	Macon	20.52	Rome	3.45
Idaho	64.5	-1.4	Cambridge	108	9	Stanley	18	29	0.25	-0.42	Cottonwood	1.20	9 stations	0.00
Illinois	75.4	+1.2	McLeansboro	99	9	Mount Carroll	44	31	3.53	+0.08	Efingham	7.13	Astoria	0.60
Indiana	74.6	+1.3	2 stations	99	9	Wheatfield	44	25	3.80	+0.49	Bloomington	5.79	Salamonia	1.39
Iowa	72.7	+1.0	Inwood	100	1	2 stations	37	24	6.42	+2.98	Decorah	12.80	Corydon	2.16
Kansas	76.9	-0.6	Oberlin	104	19	Oberlin	35	24	3.11	+0.08	Emmett	7.73	Dresden	0.32
Kentucky	77.0	+1.4	Quicksand	101	7	2 stations	54	23	4.33	+0.62	Eubank	7.35	Earlington	1.60
Louisiana	83.3	+1.6	Plain Dealing	104	21	3 stations	65	12	4.13	-1.06	Franklin	11.23	Logansport	0.00
Maryland-Delaware	75.7	+2.4	Millsboro, Del.	100	6	Oakland, Md.	41	13	9.20	+4.93	Cheltenham, Md.	18.68	Cumberland, Md.	3.23
Michigan	68.0	+1.4	Five Channels	100	10	Vanderbilt	28	25	3.50	+0.68	Bay City	8.57	Groton	0.89
Minnesota	67.1	+0.4	Fergus Falls	101	14	Meadow Lands	30	25	6.03	+2.86	Albert Lea	12.28	Hallock	1.62
Mississippi	82.6	+2.1	Holly Springs	104	13	Hernando	60	31	3.57	-0.79	Biloxi	8.85	Yazoo City	0.22
Missouri	76.4	+0.4	Clinton	99	15	Louisiana	45	22	5.35	+1.67	Galena	11.24	Hannibal	0.96
Montana	62.5	-1.9	2 stations	107	11	Conway's Ranch	21	29	1.37	+0.22	Adel	4.00	Heron	T.
Nebraska	73.8	+1.0	Greeley	109	10	Ewing	31	24	1.54	-1.27	Falls City	6.96	2 stations	T.
Nevada	70.6	-0.3	Logandale	115	9	Rye Patch	29	27	0.07	-0.37	McGill	0.45	12 stations	0.00
New England	70.1	+3.3	3 stations	98	25	2 stations	35	12	4.68	+0.74	East Hartland, Conn.	11.16	Hyannis, Mass.	0.38
New Jersey	74.5	+2.7	2 stations	99	23	Layton	45	13	6.72	+1.99	Belvidere	14.26	Ashbury Park	3.33
New Mexico	68.7	-1.7	Cambray	104	6	Selsor Ranch	25	6	3.25	+0.67	Clouderott	8.44	Tularosa	0.10
New York	70.8	+3.5	2 stations	99	24	Allegany State Park	34	13	4.63	+0.86	High Falls	10.65	Avon	0.83
North Carolina	77.6	+1.9	Weldon	101	6	2 stations	47	23	8.39	+3.19	Linville Falls	20.95	Hatteras	1.13
North Dakota	64.8	-0.6	Beach	105	11	Pembina	25	31	3.30	+1.02	Edgeley	9.17	Pembina	0.20
Ohio	74.0	+2.2	Middleport	99	9	Millport	43	31	2.65	-0.87	Ironton	6.62	Larue	0.59
Oklahoma	81.3	+0.3	2 stations	106	21	Goodwell	41	24	3.07	-0.26	Pryor	10.31	Altus	0.17
Oregon	65.1	-0.4	Pittsburg	108	8	Fremont	22	15	0.07	-0.43	Lake	0.37	48 stations	0.00
Pennsylvania	73.4	+3.4	Phoenixville	99	4	Ridgway	35	13	4.60	+0.37	Hawley	10.87	Beaver Falls	1.32
South Carolina	79.4	+0.5	2 stations	98	13	Caesars Head	50	1	10.22	+4.33	Caesars Head	20.02	Beaufort (near)	1.99
South Dakota	71.2	+1.2	Cottonwood	109	15	2 stations	32	24	2.67	+0.47	Menno	8.03	Oelrichs	0.20
Tennessee	78.4	+2.0	Perryville	101	9	Elkmont	55	20	5.25	+1.17	Elkmont	10.36	Fayetteville	1.86
Texas	83.3	+0.6	Falfurrias	110	10	Muleshoe	44	25	2.12	-0.44	Grandfalls	11.65	3 stations	0.00
Utah	69.3	-0.3	Saint George	111	9	Woodruff	28	28	0.51	-0.48	Dry Gulch Ranger Station	2.77	10 stations	0.00
Virginia	75.9	+1.9	Clarksville	103	4	Dale Enterprise	42	12	8.71	+4.21	New Canton	18.65	Langley Field	2.04
Washington	64.9	-0.8	Wahluke	106	7	Chewelah	29	28	0.22	-0.77	Cusick	1.44	11 stations	0.00
West Virginia	74.0	+2.2	Point Pleasant	103	8	Bayard	39	12	5.36	+1.41	Hinton	8.43	Dam 12, Ohio River	1.85
Wisconsin	67.9	+1.1	Sheboygan	98	8	Prentice	30	31	5.91	+2.61	Prairie du Chien	12.92	Cornucopia	2.45
Wyoming	62.4	-1.7	Basin	103	20	Riverside	15	17	0.81	-0.35	Dull Center (near)	3.02	Border	0.00
Alaska (July)	54.3	-1.1	Porcupine Creek	90	3	Wonder Lake	25	23	3.48	+0.66	Speel River	10.00	Fort Yukon	0.50
Hawaii	75.4	+0.5	2 stations	94	3	Volcano Observatory	53	15	5.33	-1.20	Eke	38.50	8 stations	0.00
Porto Rico	79.3	+0.2	Toa Alta	98	22	2 stations	61	17	10.36	+3.01	Coamo	20.94	Vieques	5.05

¹ For description of tables and charts, see Review, January, 1928, p. 29.

² Other dates also.

TABLE 1.—Climatological data for Weather Bureau stations, August, 1928

District and station	Elevation of instruments			Pressure			Temperature of the air										Precipitation			Wind					Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month		
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. +2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Total	Departure from normal	Days with 0.01, or more	Total movement	Prevailing direction	Maximum velocity								
																								Miles per hour							Direction	Date
New England																																
Eastport	76	67	85	29.95	30.03	+0.07	61.2	+0.5	90	14	68	49	21	54	30	58	57	87	3.94	+0.9	12	4,554	s.	21	e.	6	8	5	18	6.8	0.0	0.0
Greenville, Me.	1,070	6	22	28.91	30.04	0.00	64.8	0.00	89	15	73	45	21	56	31	64	61	82	4.02	0.00	16	4,234	s.	22	nw.	11	11	7	13	5.6	0.0	0.0
Portland, Me.	103	82	117	29.93	30.05	+0.07	69.4	+3.0	95	4	77	56	21	62	32	64	61	82	3.52	+0.4	14	4,234	s.	22	nw.	11	11	7	13	5.6	0.0	0.0
Concord	259	70	79	29.72	30.02	+0.04	69.6	+2.8	94	4	80	47	13	59	38	60	67	79	5.12	+1.6	15	2,947	se.	16	nw.	30	8	12	11	5.5	0.0	0.0
Burlington	403	11	48	29.58	30.00	+0.03	70.2	+2.3	90	4	79	47	12	61	31	60	67	79	2.81	-0.6	17	5,227	s.	27	s.	28	6	13	12	6.0	0.0	0.0
Northfield	876	12	60	30.03	30.03	0.00	67.6	+1.2	90	15	78	42	12	57	38	60	67	79	4.12	+0.2	14	3,840	s.	24	sw.	1	4	13	14	6.8	0.0	0.0
Boston	125	115	158	29.90	30.03	+0.04	73.6	+3.7	96	4	81	58	7	66	34	67	65	79	2.45	-1.2	11	4,911	sw.	31	nw.	30	9	9	14	6.2	0.0	0.0
Nantucket	12	14	90	30.02	30.03	+0.04	70.6	+2.6	87	15	77	56	22	64	20	66	65	89	0.57	-2.5	6	8,294	sw.	30	ne.	12	10	10	11	5.3	0.0	0.0
Block Island	26	11	46	30.00	30.02	+0.03	70.6	+2.1	85	15	76	60	22	65	18	67	65	88	2.01	-1.7	7	8,347	sw.	37	sw.	11	5	15	11	6.0	0.0	0.0
Providence	150	215	251	29.87	30.04	+0.05	73.2	+2.5	95	4	82	54	13	65	30	67	65	78	4.03	+0.5	11	5,222	sw.	26	nw.	5	10	10	11	5.4	0.0	0.0
Hartford	159	122	159	29.87	30.04	+0.05	73.6	+4.7	96	4	82	54	13	65	29	68	66	81	4.08	-0.2	14	4,771	sw.	24	ne.	12	10	10	11	5.5	0.0	0.0
New Haven	106	74	133	29.92	30.03	+0.04	74.0	+3.7	96	4	88	56	13	66	27	68	66	81	3.51	-0.8	15	4,771	sw.	24	ne.	12	12	8	11	5.3	0.0	0.0
Middle Atlantic States																																
Albany	97	102	115	29.92	30.02	+0.04	73.0	+2.2	92	30	81	54	13	64	30	68	66	83	4.12	+0.4	14	4,138	s.	23	s.	24	13	10	8	4.8	0.0	0.0
Binghamton	871	10	84	29.11	30.02	+0.03	72.5	+4.5	92	3	82	49	13	62	32	68	66	79	2.32	-1.0	12	2,880	e.	20	sw.	10	10	8	13	6.0	0.0	0.0
New York	314	414	454	29.70	30.03	+0.03	74.4	+1.3	90	4	81	61	23	68	19	68	66	79	4.26	-0.1	15	8,143	s.	45	s.	10	5	12	14	6.8	0.0	0.0
Harrisburg	374	94	104	29.64	30.03	+0.02	75.0	+2.4	93	4	83	58	14	66	26	68	66	79	3.64	-0.6	15	3,333	sw.	18	n.	11	4	9	18	6.9	0.0	0.0
Philadelphia	114	123	341	29.92	30.04	+0.04	77.2	+2.4	95	4	85	59	12	70	20	70	67	77	5.47	+0.8	12	5,982	sw.	44	ne.	12	4	13	14	6.5	0.0	0.0
Reading	325	81	98	29.68	30.02	0.00	75.7	0.00	94	4	84	58	13	67	27	69	66	77	4.82	+0.3	13	3,475	sw.	22	ne.	12	9	10	12	6.3	0.0	0.0
Scranton	805	111	119	29.19	30.04	+0.04	72.9	+3.1	91	4	82	52	13	64	32	67	65	81	6.04	+1.8	17	3,647	s.	23	w.	30	3	11	17	7.4	0.0	0.0
Atlantic City	52	37	172	29.97	30.02	+0.02	74.7	+2.2	87	18	80	59	12	69	23	70	69	85	6.20	+1.7	7	10,517	s.	62	ne.	12	13	11	7	4.4	0.0	0.0
Cape May	17	13	49	30.00	30.00	0.00	74.8	+1.4	90	30	81	60	12	68	23	71	70	90	5.46	0.00	6	0.00	s.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sandy Hook	22	10	55	30.00	30.02	0.00	74.6	0.00	93	4	80	61	22	69	20	70	68	84	6.31	0.00	17	7,923	sw.	43	ne.	12	9	9	13	6.3	0.0	0.0
Trenton	100	159	183	29.82	30.02	0.00	75.5	0.00	96	4	84	57	12	67	26	69	67	82	3.40	-2.0	12	5,746	sw.	35	ne.	12	7	9	15	6.6	0.0	0.0
Baltimore	123	100	215	29.89	30.01	0.00	77.8	+2.3	97	3	86	57	12	70	24	71	68	76	9.70	+5.3	11	5,198	sw.	35	n.	12	11	7	13	5.8	0.0	0.0
Washington	112	62	85	29.91	30.02	+0.01	77.0	+2.0	97	4	86	57	12	68	28	70	69	83	14.41	+10.4	12	2,610	s.	27	n.	21	7	11	13	6.2	0.0	0.0
Cape Henry	18	8	54	30.00	30.02	0.00	78.2	0.00	96	4	86	59	14	71	22	73	71	81	2.64	-2.2	9	6,124	sw.	33	nw.	12	15	11	5	4.5	0.0	0.0
Lynchburg	681	153	188	29.31	30.04	+0.02	77.4	+1.8	98	6	86	60	13	68	28	70	68	81	14.87	+11.1	18	3,569	w.	28	s.	10	5	17	9	5.6	0.0	0.0
Norfolk	91	170	205	29.95	30.04	+0.04	79.4	+2.0	94	7	88	61	13	71	24	72	69	78	2.05	-3.2	9	6,975	s.	39	w.	12	10	13	8	5.0	0.0	0.0
Richmond	144	11	52	29.89	30.04	+0.03	78.0	+1.5	97	4	87	58	12	69	24	71	70	85	8.05	+3.6	15	3,913	sw.	27	nw.	30	9	15	7	5.2	0.0	0.0
Wytheville	2,304	49	55	27.74	30.04	+0.03	71.9	+1.4	87	2	81	56	23	63	26	67	65	88	5.44	+1.2	18	2,725	w.	18	nw.	5	5	16	10	6.2	0.0	0.0
South Atlantic States																																
Asheville	2,253	70	84	27.75	30.04	+0.02	73.0	+2.5	87	4	82	58	23	64	20	67	65	88	9.08	+4.5	16	3,667	se.	24	n.	5	5	18	8	5.9	0.0	0.0
Charlotte	779	55	62	29.22	30.04	+0.02	79.8	+2.7	97	4	89	66	13	70	25	73	71	86	13.14	+8.1	15	2,324	sw.	19	nw.	11	6	17	8	6.0	0.0	0.0
Hatteras	11	11	50	30.04	30.05	+0.05	79.7	+1.7	92	8	86	66	13	74	17	75	73	80	1.13	-4.6	7	6,317	sw.	38	sw.	11	17	6	8	4.3	0.0	0.0
Raleigh	376	103	110	29.65	30.04	+0.03	78.6	+1.6	95	3	88	61	13	70	23	72	71	84	10.41	+4.5	13	3,863	sw.	29	sw.	11	5	16	10	6.3	0.0	0.0
Wilmington	78	81	91	29.98	30.06	+0.06	80.0	+2.4	92	19	87	65	13	73	22	75	74	86	7.11	+0.8	11	4,110	sw.	28	sw.	11	10	14	7	5.1	0.0	0.0
Charleston	48	11	92	30.00	30.06	+0.06	82.0	+1.0	93	19	88	72	13	76	16	78	76	85	2.82	-3.7	11	6,603	sw.	36	s.	10	4	18	9	5.9	0.0	0.0
Columbia, S. C.	351	41	57	29.67	30.05	+0.04	80.4	+0.8	94	7	89	69	21	72	23	73	72	83	10.19	+3.4	15	3,811	s.	33	sw.	11	9	14	8	5.5	0.0	0.0
Due West	711	10	55	29.31	30.07	0.00	78.6	0.00	93	5	88	66	20	69	23	71	69	83	13.90	0.00	14	4,660	sw.	36	nw.	31	6	20	5	5.6	0.0	0.0
Greenville, S. C.	1,039	139	146	28.97	30.04	+0.04	77.9	+2.1	92	8	86	66	20	69	23	71	69	83	13.36	0.00	12	4,654	sw.	36	n.	11	5	18	8	5.9	0.0	0.0
Augusta	182	62	77	29.83	30.02	+0.01	81.6	+1.2	96	3	90	70	14	73	24	74	72	82	8.44	+3.4	18	3,338	s.	25	se.	10	5	18	8	5.8	0.0	0.0
Savannah	65	150	194	29.98	30.05	+0.04	81.2	+0.5	93	22	88	70	27	74	20	75	74	84	6.29													

TABLE 1.—Climatological data for Weather Bureau stations, August, 1928—Continued

District and station	Elevation of instruments			Pressure			Temperature of the air										Precipitation			Wind					Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month						
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. +2	Departure from normal	Maximum	Minimum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Total	Departure from normal	Days with 0.01, or more	Total movement	Prevailing direction				Maximum velocity					
																												Miles per hour	Direction	Date	Clear days	Partly cloudy days	Cloudy days
Ohio Valley and Tennessee																																	
Chattanooga	762	190	215	29.23	30.02	+0.02	78.2	+0.7	91	5	87	63	23	70	28	71	68	79	4.66	+0.6	15	3,815	sw.	42	sw.	30	4	21	6	5.5	0.0	0.0	
Knoxville	966	102	111	29.01	30.04	+0.03	77.4	+1.2	93	2	87	63	21	68	25	70	69	82	4.58	+0.7	13	3,309	sw.	25	w.	4	5	20	6	5.8	0.0	0.0	
Memphis	399	76	97	29.58	30.00	+0.02	81.2	+1.8	94	14	89	61	31	74	21	74	71	76	3.91	+0.6	9	4,139	sw.	24	w.	30	10	14	7	4.9	0.0	0.0	
Nashville	546	168	191	29.47	30.04	+0.04	78.9	+1.1	92	5	88	62	31	70	25	71	69	77	4.62	+0.9	9	4,275	sw.	33	nw.	21	9	16	6	5.2	0.0	0.0	
Lexington	980	193	230	29.00	30.04	+0.03	75.2	+0.7	90	9	83	60	13	68	23	68	63	72	4.30	+0.7	12	6,322	sw.	31	sw.	14	9	15	7	5.2	0.0	0.0	
Louisville	525	188	234	29.46	30.04	+0.04	77.0	0.0	92	9	85	62	12	69	25	70	68	79	3.23	-0.2	11	5,195	s.	28	se.	23	11	14	6	4.6	0.0	0.0	
Evansville	431	76	116	29.58	30.04	+0.05	79.0	+1.6	95	7	88	62	25	70	25	70	68	75	1.41	-2.0	12	4,508	s.	32	nw.	10	7	16	8	5.5	0.0	0.0	
Indianapolis	822	194	230	29.15	30.02	+0.02	74.6	+0.9	91	9	84	55	12	65	28	66	63	72	3.81	+0.5	10	5,862	s.	42	s.	21	13	15	3	4.3	0.0	0.0	
Royal Center	736	11	55	29.24	30.02	+0.02	71.0	0.0	91	2	82	48	19	60	34	67	63	72	7.42	0.0	11	4,669	s.	32	nw.	21	10	15	6	5.0	0.0	0.0	
Terre Haute	575	96	129	29.40	30.01	+0.01	75.7	0.0	92	28	86	56	25	66	28	68	65	74	4.06	0.0	8	4,796	s.	30	nw.	10	9	17	5	5.0	0.0	0.0	
Cincinnati	627	11	51	29.36	30.03	+0.02	75.6	+2.0	93	10	86	56	12	66	29	68	66	76	2.85	-0.6	10	3,395	sw.	22	s.	21	12	11	8	4.8	0.0	0.0	
Columbus	822	179	222	29.18	30.03	+0.02	75.1	+2.1	92	9	84	56	12	66	25	67	63	73	1.05	-2.2	5	4,968	s.	29	nw.	17	12	16	3	4.5	0.0	0.0	
Dayton	869	137	173	29.08	30.01	+0.01	75.4	+2.0	93	8	86	55	12	65	29	67	63	73	3.00	-0.3	9	4,646	ne.	35	w.	17	5	21	5	5.5	0.0	0.0	
Elkins	1,947	59	67	28.06	30.04	+0.02	70.9	+1.8	87	3	80	54	23	62	30	65	64	87	4.77	+1.1	17	2,188	w.	16	nw.	24	3	10	18	7.3	0.0	0.0	
Parkersburg	637	77	82	29.40	30.05	+0.04	76.3	+2.4	93	20	85	57	23	67	28	68	66	80	4.75	+1.2	12	2,815	sw.	24	nw.	2	6	9	16	6.8	0.0	0.0	
Pittsburgh	842	353	410	29.14	30.02	+0.01	74.4	+1.5	90	9	83	57	13	66	29	67	64	76	3.10	-0.1	11	5,710	sw.	29	nw.	5	6	14	11	5.7	0.0	0.0	
Lower Lake Region																																	
Buffalo	767	247	280	29.19	30.01	+0.02	71.0	+2.4	91	15	78	55	26	64	29	66	64	82	1.84	-1.2	11	8,145	sw.	48	w.	21	14	12	5	4.6	0.0	0.0	
Canton	448	10	61	29.53	30.09	+0.06	69.6	+1.8	91	16	80	46	12	60	32	66	64	82	3.23	+0.5	13	4,623	sw.	26	w.	21	9	12	10	5.4	0.0	0.0	
Ithaca	836	5	100	29.12	30.00	+0.02	70.6	0.0	90	4	81	46	13	60	32	65	63	82	3.04	-0.3	12	4,721	nw.	29	nw.	21	5	15	11	5.9	0.0	0.0	
Oswego	335	76	91	29.64	30.01	+0.02	70.8	+2.4	90	28	78	56	12	64	25	66	64	79	2.66	+0.1	10	4,571	s.	23	sw.	21	8	11	12	5.6	0.0	0.0	
Rochester	523	86	102	29.46	30.02	+0.03	72.0	+2.8	91	4	81	52	13	64	28	65	61	73	3.25	+0.4	10	3,982	sw.	24	w.	21	12	9	10	5.4	0.0	0.0	
Syracuse	597	97	113	29.39	30.03	+0.04	71.8	+2.3	90	4	80	53	13	64	28	65	61	73	4.98	+1.6	15	5,294	s.	30	se.	16	6	14	11	6.2	0.0	0.0	
Erie	714	130	166	29.27	30.02	+0.01	72.4	+2.8	91	3	80	53	13	65	24	66	63	74	3.89	+0.6	10	7,122	nw.	32	nw.	10	12	17	2	4.4	0.0	0.0	
Cleveland	762	190	201	29.21	30.02	+0.01	72.8	+2.8	92	3	80	56	13	66	23	66	62	70	1.15	-1.6	6	6,569	ne.	34	w.	4	12	13	6	4.7	0.0	0.0	
Sandusky	629	8	67	29.35	30.02	+0.01	74.1	+2.3	96	3	83	54	31	65	29	65	62	72	2.92	-0.2	9	4,438	ne.	23	nw.	9	10	15	6	4.7	0.0	0.0	
Toledo	628	208	243	29.35	30.03	+0.03	72.9	+1.6	94	3	82	53	25	64	30	65	62	72	2.68	-0.2	12	7,042	sw.	44	sw.	4	18	12	1	3.2	0.0	0.0	
Fort Wayne	856	113	124	29.11	30.02	+0.03	73.4	+2.3	94	8	84	52	25	63	32	65	62	72	1.96	0.0	10	4,717	sw.	26	sw.	21	12	16	3	4.5	0.0	0.0	
Detroit	730	218	258	29.25	30.02	+0.01	73.2	+2.9	92	3	82	53	25	64	27	65	61	71	2.02	-0.8	8	5,368	sw.	26	ne.	11	11	15	5	4.6	0.0	0.0	
Upper Lake Region																																	
Alpena	609	13	92	29.36	30.02	+0.02	64.6	+0.5	84	2	74	41	25	56	25	61	58	80	3.96	+1.1	8	6,325	se.	36	se.	29	14	11	6	4.3	0.0	0.0	
Escanaba	612	54	60	29.34	29.99	+0.00	64.9	+0.6	88	7	72	43	31	58	23	61	58	81	5.44	+2.2	11	6,267	s.	39	ne.	21	13	11	7	4.5	0.0	0.0	
Grand Haven	632	54	89	29.33	30.00	+0.01	65.1	+1.0	87	16	77	48	31	60	26	63	61	78	2.34	-0.5	8	5,797	s.	25	s.	20	14	11	6	4.3	0.0	0.0	
Grand Rapids	707	70	87	29.26	30.01	+0.01	71.3	+1.6	92	15	81	49	25	61	31	63	50	70	4.46	+1.8	8	3,160	w.	18	sw.	21	9	13	9	5.2	0.0	0.0	
Houghton	668	64	99	29.26	29.97	+0.00	64.3	+0.6	89	14	74	46	25	55	31	64	62	82	2.39	-0.5	10	5,080	e.	29	w.	30	9	11	11	5.6	0.0	0.0	
Lansing	878	6	49	29.09	30.01	+0.00	69.0	+0.5	91	2	80	45	25	58	33	64	62	82	2.79	0.0	12	2,636	sw.	15	w.	20	16	9	6	4.0	0.0	0.0	
Ludington	637	60	68	29.31	30.00	+0.00	65.6	0.0	85	9	73	45	25	58	26	61	58	78	2.66	0.0	10	5,542	s.	42	sw.	20	18	8	5	3.5	0.0	0.0	
Marquette	734	77	111	29.20	29.99	+0.01	64.2	+0.4	85	14	72	46	31	56	27	59	57	81	4.48	+1.8	13	5,723	s.	26	w.	21	9	7	15	6.0	0.0	0.0	
Port Huron	638	70	120	29.33	30.02	+0.02	70.2	+2.4	89	3	79	51	31	62	25	64	62	80	4.36	+1.7	12	5,819	ne.	30	n.	21	14	11	2	3.6	0.0	0.0	
Sault Ste. Marie	614	11	52	29.32	30.01	+0.02	64.2	+2.2	92	16	74	40	25	54	30	59	56	81	4.06	+1.0	11	4,454	se.	31	nw.	21	14	11	6	4.8	0.0	0.0	
Chicago	673	7	131	29.30	30.02	+0.02	72.2	+0.6	91	3	79	58	31	65	26	66	63	79	5.03	+1.8	8	6,135	ne.	29	sw.	3	13	11	7	4.4	0.0	0.0	
Green Bay	617	109	141	29.33	29.99	+0.00	68.4	+0.7	93	8	78	45	31	59	31	62	59	74	3.82	+0.7	12	6,051	s.	32	sw.	20	15	10	6	4.4	0.0	0.0	
Milwaukee	681	125	221	29.28	30.01	+0.01	70.6	+1.0	93	8	78	51	31	63	23	64	60	73	4.02	+1.4	9	7,582	se.	28	sw.	20	18	6	7	3.9	0.0	0.0	
Duluth	1,133	5	47	28.77	29.97	+0.00	63.6	+1.0	89	9	72	44	31	55	28	59	57	86	4.03	+0.8	11	6,198	ne.										

TABLE 1.—Climatological data for Weather Bureau stations, August, 1928—Continued

District and station	Elevation of instruments			Pressure			Temperature of the air										Precipitation			Wind																																														
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. +2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Total	Departure from normal	Days with 0.01, or more	Total movement	Prevailing direction	Maximum velocity			Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month																																		
																								Miles per hour	Direction	Date																																								
Ft.	Ft.	Ft.	In.	In.	In.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	%	In.	In.		Miles																																													
Northern Slope																																		0.82	-0.5																															
Billings	3,140	5				+0.06	64.7		101	11	83	38	30	46	52				0.90			nw.																																												
Havre	2,505	11	44	27.36	29.97		63.6	-1.8	98	10	77	36	23	50	41	53	46	62	1.88	+0.7	9	3,435	sw.	19	w.	18	15	7	9	4.5	0.0	0.0																																		
Helena	4,110	87	112	25.84	29.97	+0.03	63.1	-1.9	98	10	76	43	29	50	39	52	44	60	1.99	+1.3	7	5,152	sw.	23	n.	24	15	9	7	4.1	0.0	0.0																																		
Kalispell	2,973	48	56	26.95	29.96	+0.03	60.8	-2.0	94	10	75	36	28	47	44	50	41	57	1.14	+0.2	7	3,950	nw.	34	sw.	10	15	11	5	3.7	0.0	0.0																																		
Miles City	2,371	48	55	27.46	29.96	+0.03	68.8	-2.7	104	11	82	41	24	55	42	55	45	52	0.14	-0.9	7	3,301	n.	33	nw.	1	20	8	3	3.0	0.0	0.0																																		
Rapid City	3,259	50	58	26.62	29.96	+0.03	69.8	+0.3	98	13	83	44	31	57	37	57	49	53	0.42	-1.7	4	4,824	n.	30	n.	22	16	10	5	3.5	0.0	0.0																																		
Cheyenne	6,088	84	101	24.11	29.94	+0.02	65.0	-0.4	89	12	79	42	23	52	35	50	39	46	0.53	-1.0	7	6,539	w.	31	nw.	19	12	14	5	4.4	0.0	0.0																																		
Lander	5,372	60	68	24.71	29.95	+0.03	65.2	-0.5	94	9	82	39	29	48	44	50	39	48	0.24	-0.3	4	3,610	w.	36	nw.	22	20	10	1	3.0	0.0	0.0																																		
Sheridan	3,790	10	47	26.12	29.97		64.3		99	11	81	37	30	47	50	53	46	63	0.65		8	2,533	nw.	25	nw.	13	17	11	3	3.4	0.0	0.0																																		
Yellowstone Park	6,241	11	48	23.98	30.00	+0.07	56.6	-4.3	89	10	72	30	29	41	41	44	35	54	0.96	-0.1	9	4,548	sw.	29	sw.	14	11	13	7	4.5	0.0	0.0																																		
North Platte	2,821	11	51	27.08	29.94	.00	73.6	+2.8	99	9	87	39	24	60	41	61	55	60	0.11	-2.3	1	3,762	s.	26	n.	22	21	8	2	2.8	0.0	0.0																																		
Middle slope																																		2.04	-0.4																															
Denver	5,292	106	113	24.81	29.96	+0.04	70.6	-0.1	96	19	83	49	23	58	34	54	43	43	0.85	-0.6	7	4,838	s.	31	n.	22	15	12	4	4.1	0.0	0.0																																		
Pueblo	4,685	80	86	25.36	29.95	+0.04	72.4	-0.3	98	20	87	51	8	58	43	55	40	48	0.49	-1.1	7	3,912	se.	30	nw.	1	13	15	3	4.0	0.0	0.0																																		
Concordia	1,392	60	88	28.53	29.97	+0.02	76.5	-0.9	97	27	87	47	24	60	35	68	40	71	5.47	+2.6	10	4,384	s.	24	nw.	7	18	8	5	3.9	0.0	0.0																																		
Dodge City	2,509	11	51	27.44	29.98	+0.05	75.8	-1.9	95	1	88	44	24	63	34	64	59	65	2.78	+0.1	6	5,512	s.	27	sw.	2	23	5	3	2.7	0.0	0.0																																		
Wichita	1,358	139	138	28.55	29.94	-0.01	79.8	+1.5	100	11	91	52	24	69	29	68	64	66	0.70	-2.4	7	6,714	s.	36	sw.	3	15	12	4	4.0	0.0	0.0																																		
Broken Arrow	765	11	56	29.17	29.99		79.2		94	28	88	60	24	70	26				10.11		7	6,218	s.	30	w.	17	16	6	9	4.3	0.0	0.0																																		
Oklahoma City	1,214	10	47	28.71	29.95	+0.01	82.0	+2.3	100	21	93	62	24	71	28	70	66	67	1.98	-1.2	7	5,264	s.	32	sw.	9	17	7	7	4.3	0.0	0.0																																		
Southern slope																																		4.62	+2.2																															
Abilene	1,738	16	52	28.19	29.95	+0.03	80.8	-1.2	97	23	91	60	24	71	30	70	65	67	5.61	+3.4	7	4,748	s.	28	w.	23	17	8	6	3.8	0.0	0.0																																		
Amarillo	3,676	10	49	28.33	29.97	+0.05	74.6	-1.1	92	6	85	49	25	64	25	64	60	66	6.15	+3.3	8	5,452	s.	29	s.	13	15	12	4	4.1	0.0	0.0																																		
Del Rio	944	64	71	28.93	29.89	-0.01	85.6	+1.4	101	30	95	68	8	76	25	72	66	60	2.35	-0.2	5	5,880	se.	26	ne.	18	19	10	2	3.3	0.0	0.0																																		
Roswell	3,560	75	85	26.41	29.95	+0.07	74.0	-0.6	94	6	84	54	25	64	29	64	60	70	4.36	+2.4	12	4,314	s.	26	se.	17	8	17	6	4.9	0.0	0.0																																		
Southern Plateau																																		1.70	+0.3																															
El Paso	3,778	152	175	26.21	29.90	+0.06	77.8	-1.4	97	7	88	62	24	68	27	64	58	58	2.69	+1.0	12	5,433	e.	48	se.	27	12	17	2	4.3	0.0	0.0																																		
Santa Fe	7,013	38	53	23.38	29.93	+0.04	65.4	-2.0	88	20	77	48	26	54	32	53	47	63	2.80	+0.3	15	3,308	e.	22	ne.	13	11	12	8	5.0	0.0	0.0																																		
Flagstaff	6,907	10	59	23.48	29.89	+0.05	68.8	+1.0	88	20	78	40	6	50	42	51		61	1.82		12		nw.			26	9	14	8		0.0	0.0																																		
Phoenix	1,108	10	82	28.68	29.79	.00	88.4	-0.1	112	8	101	65	26	75	43	69	58	42	1.47	+0.5	6	2,954	e.	43	s.	26	17	12	2	3.2	0.0	0.0																																		
Yuma	141	9	54	29.64	29.78	+0.02	90.7	+0.3	114	8	105	68	6	77	40	73	63	48	0.04	-0.5	1	3,398	sw.	28	s.	21	28	3	0	0.8	0.0	0.0																																		
Independence	3,957	6	27	25.94	29.88	+0.07	77.0	+0.9	102	9	93	52	27	61	40	53			T.		0		nw.				25	5	1	1.0	0.0	0.0																																		
Middle Plateau																																		0.52	-0.3																															
Reno	4,532	74	81	25.49	29.90	+0.06	70.2	+3.2	99	9	89	47	23	52	44	50	35	34	0.33	+0.1	2	4,521	w.	25	w.	3	29	2	0	0.9	0.0	0.0																																		
Tonopah	6,090	12	20				72.7		94	9	85	50	26	61	27	49	27	20	0.08		1		w.																																											
Winnemucca	4,344	18	56	25.64	29.96	+0.08	68.4	-0.9	101	9	88	42	23	49	52	50	34	34	0.02	-0.2	1	3,781	sw.	25	nw.	3	27	3	1	1.7	0.0	0.0																																		
Modena	5,473	10	43	24.66	29.87	+0.01	69.5	+0.3	96	9	87	41	27	52	45	50	34	36	0.96	-0.9	6	7,076	sw.	36	ne.	10	26	4	1	1.7	0.0	0.0																																		
Salt Lake City	4,360	163	203	25.62	29.89	+0.02	74.5	-0.0	99	10	86	54	24	63	34	53	36	28	0.17	-0.7	2	5,099	s.	30	s.	25	22	7	2	2.3	0.0	0.0																																		
Grand Junction	4,602	60	68	25.41	29.93	+0.03	73.7	-1.7	97	19	87	53	24	60	35	55	41	39	1.10	+0.1	8	4,220	se.	28	sw.	1	17	10	4	3.6	0.0	0.0																																		
Northern Plateau																																		0.07	-0.4																															
Baker	3,471	48	53	25.48	30.01	+0.06	63.9	-0.7	96	8	81	35	28	47	45	49	36	41	0.06	-0.3	1	3,708	nw.	13	nw.	14	24	4	3	1.9	0.0	0.0																																		
Boise	2,739	78	86	27.14	29.94	+0.01	71.2	-0.6	104	10	87	48	28	56	42	53	38	34	0.02	-0.2	1	3,133	nw.	18	n.	4	26	3	2	1.6	0.0	0.0																																		
Lewiston	757	40	48	29.16	29.96	+0.01	72.6	-0.2	101	9	89	46	29	56	43				0.03	-0.3	2	2,242	e.	18	n.	25	22	6	3	2.2	0.0	0.0																																		
Pocatello	4,477	60	68	25.49	29.91	-0.01	68.8	+0.8	100	9	84	41	29	54	45	49	32	32	0.12	-0.4	2	4,898	se.	38	sw.	22	21	8	2	2.9	0.0	0.0																																		
Spokane	1,929	101	110	27.95	29.96	+0.01	68.4	-0.3	96	10	83	43	28	54	40	52	38	37	T.	-0.6	0	3,804	s.	22	s.	1	21	9	1	2.3	0.0	0.0																																		
Walla Walla	991	57	65	28.90	29.96	.00	73.2	+0.5	98	9	86	50	28	60	36	56	41	37	0.18	-0.3	2	2,933	w.	15	w.	21	27	3	1	1.6	0.0	0.0																																		
North Pacific Coast Region																																		0.14	-0.7																															
North Head	211	11	56	29.85	30.07	+0.04	67.2	-0.4	66	7	61	46	30	54	10	55	54	91	0.20	-0.7	7	8,156	n.	36	nw.	13	4	8	19	7.5	0.0	0.0																																		
Port Angeles	29	8	53		30.08		67.8		75	10	66	43	16	50	26				0.12	-0.5	2	4,258	nw.	27	n.	11	16	10	5																																					

¹ Observations taken bi-hourly.¹ Pressure not reduced to mean of 24 hours.

TABLE 2.—Data furnished by the Canadian Meteorological Service, August, 1928

Station	Altitude above sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Depart- ure from normal	Mean max. + mean min. ÷ 2	Depart- ure from normal	Mean maxi- mum	Mean mini- mum	Highest	Lowest	Total	Depart- ure from normal	Total snowfall
	Feet	Inches	Inches	Inches	°F.	°F.	°F.	°F.	°F.	°F.	Inches	Inches	Inches
Cape Race, N. F.	99				57.4		64.0	50.8	70	38	2.87		
Sydney, C. B. I.	48												
Halifax, N. S.	88												
Yarmouth, N. S.	65												
Charlottetown, P. E. I.	38												
Chatham, N. B.	28												
Father Point, Que.	20												
Quebec, Que.	296	29.70	30.02	+0.09	66.6	+3.5	74.0	59.3	87	48	4.54	+0.71	
Doucet, Que.	1,236				63.0		72.0	54.0	88	40	3.08		
Montreal, Que.	187	29.78	29.98	+0.03	70.5	+4.1	78.9	62.1	91	52	4.36	+0.79	
Ottawa, Ont.	236	29.74	30.00	+0.04	70.3	+5.5	80.7	60.0	92	51	3.66	+0.63	
Kingston, Ont.	285	29.70	30.00	+0.02	69.6	+2.6	76.4	62.8	83	53	4.75	+2.37	
Toronto, Ont.	379	29.60	29.99	.00	70.5	+4.5	80.1	60.9	90	52	4.99	+2.23	
Cochrane, Ont.	930				62.4		73.5	51.3	88	36	5.14		
White River, Ont.	1,244	28.66	29.95	-0.01	59.2	+2.8	71.0	47.4	88	30	6.12	+2.82	
London, Ont.	808				70.1		81.5	58.7	90	44	6.05		
Southampton, Ont.	656	29.31	30.02	+0.03	66.1	+2.3	75.2	57.1	86	45	3.01	+0.76	
Parry Sound, Ont.	688	29.32	30.00	+0.02	67.1	+3.6	75.4	58.9	83	50	3.32	+0.60	
Port Arthur, Ont.	644	29.28	29.99	+0.03	62.1	+2.6	70.1	54.2	85	39	3.89	+1.14	
Winnipeg, Man.	760	29.12	29.94	.00	64.0	+0.6	75.1	53.0	92	38	3.18	+0.51	
Minnedosa, Man.	1,690	28.15	29.94	.00	58.5	-0.9	70.3	46.8	84	30	2.45	+0.35	
Le Pas, Man.	860				57.2		68.6	45.9	94	30	1.31		
Qu'Appelle, Sask.	2,115	27.73	29.95	+0.02	59.8	-1.7	74.0	45.6	88	32	0.18	-1.46	
Moose Jaw, Sask.	1,759				62.0		78.4	45.6	98	30	0.34		
Swift Current, Sask.	2,392	27.42	29.90	-0.03	62.9	-1.1	78.8	47.0	96	29	0.40	-1.51	
Medicine Hat, Alb.	2,144												
Calgary, Alb.	3,428												
Banff, Alb.	4,521												
Prince Albert, Sask.	1,450	28.41	29.97	+0.05	58.0	-0.9	70.4	45.7	94	34	1.14	-1.01	
Battleford, Sask.	1,592	28.22	29.94	+0.03	59.5	-3.1	74.0	44.9	96	32	1.08	-1.28	
Edmonton, Alb.	2,150												
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.81	30.06	+0.05	58.9	+0.2	65.9	51.9	78	48	0.23	-0.37	
Barkerville, B. C.	4,180												
Estevan Point, B. C.	20												
Prince Rupert, B. C.	170												
Hamilton, Ber.	151	29.99	30.15	+0.05	79.1	-0.5	86.6	71.7	90	69	6.64	+0.56	

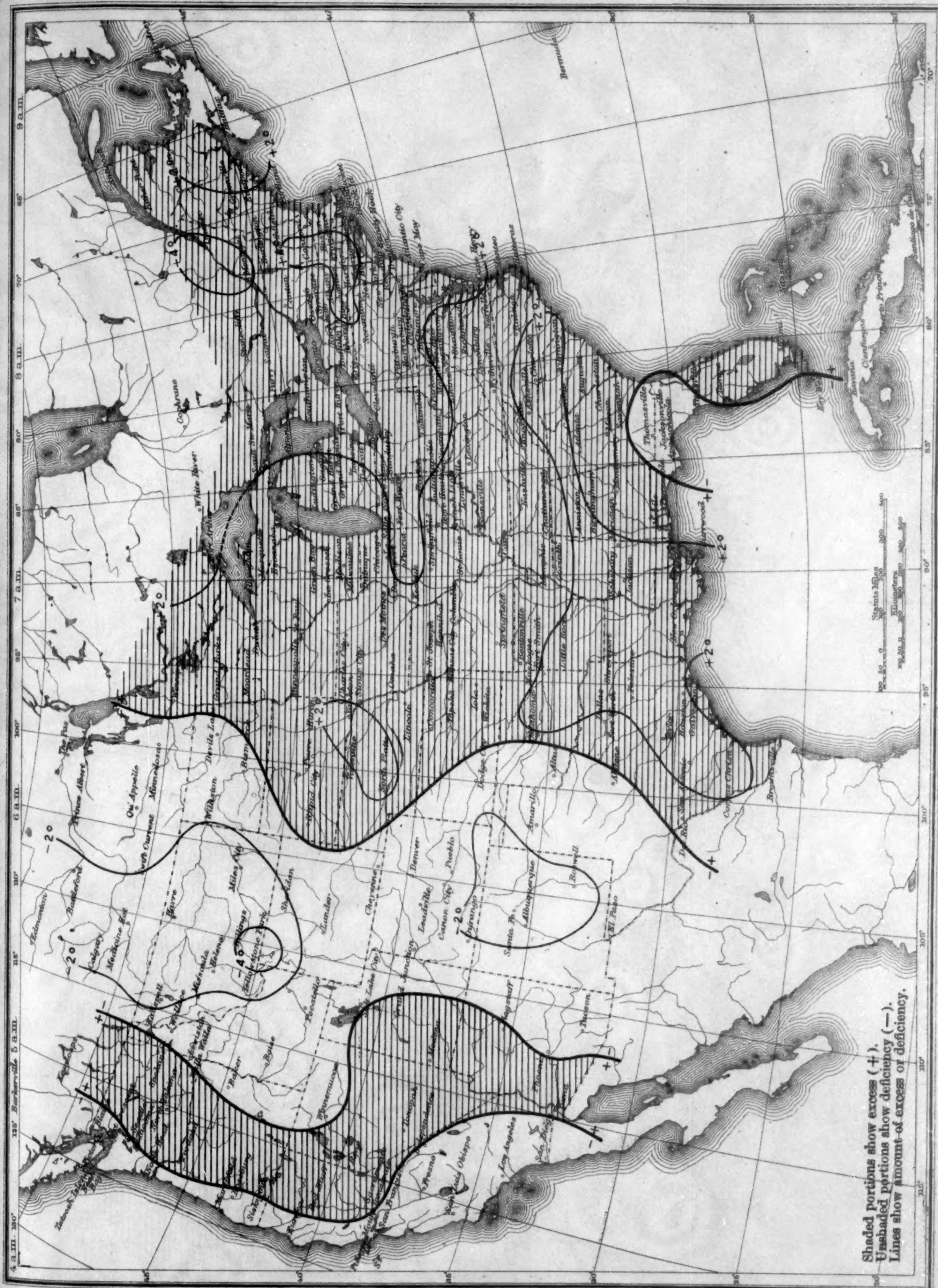
LATE REPORTS, JULY, 1928

Cape Race, N. F.	99				56.0		63.8	48.1	72	38	3.81		
Sydney, C. B. I.	48	29.87	29.92	-0.01	64.9	+2.6	73.9	55.9	85	40	3.74	+0.09	
Halifax, N. S.	88	29.86	29.96	-0.00	66.2	+2.8	75.5	56.0	85	48	2.48	-1.57	
Yarmouth, N. S.	65	29.83	29.90	-0.05	61.7	+2.2	68.2	55.2	79	48	4.27	+0.80	
Charlottetown, P. E. I.	38	29.81	29.85	-0.05	66.6	+2.5	73.7	59.6	82	50	2.95	-0.54	
Chatham, N. B.	28	29.79	29.82	-0.06	66.0	+1.0	76.6	55.4	88	38	2.28	-1.91	
Ottawa, Ont.	236	29.66	29.92	-0.02	69.7	+0.2	79.4	60.1	89	50	4.03	+0.56	
Winnipeg, Man.	760	29.11	29.92	-0.01	67.4	+1.4	77.1	57.7	90	48	4.44	+1.36	
Qu'Appelle, Sask.	2,115	27.73	29.94	+0.02	63.6	+0.1	74.0	53.1	85	42	1.87	-0.61	
Medicine Hat, Alb.	2,144	27.64	29.85	-0.05	68.4	+0.6	80.6	56.3	94	48	2.36	+0.27	
Calgary, Alb.	3,428	26.45	29.96	+0.06	62.1	+1.5	74.6	49.5	90	38	1.53	-1.15	
Banff, Alb.	4,521	25.44	29.93	+0.03	60.0	+3.4	74.4	45.6	88	38	1.59	-1.65	
Edmonton, Alb.	2,150	27.65	29.89	-0.01	62.2	+1.6	73.6	50.9	88	43	4.94	+1.91	
Kamloops, B. C.	1,262	28.64	29.90	-0.04	72.0	+3.5	84.4	59.7	100	52	1.14	-0.47	
Victoria, B. C.	230	29.76	30.01	-0.04	61.0	+1.0	68.9	53.2	90	50	0.25	-0.15	
Estevan Point, B. C.	20				57.3		63.0	51.6	72	47	1.26		
Prince Rupert, B. C.	170				57.8		64.5	51.2	72	44	4.62		
Hamilton, Ber.	151	30.05	30.21	+0.07	79.5	+0.8	87.1	71.9	90	69	3.50	-0.94	

August 1923										Normal									
Day	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Day	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue
1	75	78	80	82	85	88	90	75	78	1	75	78	80	82	85	88	90	75	78
2	76	79	81	83	86	89	91	76	79	2	76	79	81	83	86	89	91	76	79
3	77	80	82	84	87	90	92	77	80	3	77	80	82	84	87	90	92	77	80
4	78	81	83	85	88	91	93	78	81	4	78	81	83	85	88	91	93	78	81
5	79	82	84	86	89	92	94	79	82	5	79	82	84	86	89	92	94	79	82
6	80	83	85	87	90	93	95	80	83	6	80	83	85	87	90	93	95	80	83
7	81	84	86	88	91	94	96	81	84	7	81	84	86	88	91	94	96	81	84
8	82	85	87	89	92	95	97	82	85	8	82	85	87	89	92	95	97	82	85
9	83	86	88	90	93	96	98	83	86	9	83	86	88	90	93	96	98	83	86
10	84	87	89	91	94	97	99	84	87	10	84	87	89	91	94	97	99	84	87
11	85	88	90	92	95	98	100	85	88	11	85	88	90	92	95	98	100	85	88
12	86	89	91	93	96	99	101	86	89	12	86	89	91	93	96	99	101	86	89
13	87	90	92	94	97	100	102	87	90	13	87	90	92	94	97	100	102	87	90
14	88	91	93	95	98	101	103	88	91	14	88	91	93	95	98	101	103	88	91
15	89	92	94	96	99	102	104	89	92	15	89	92	94	96	99	102	104	89	92
16	90	93	95	97	100	103	105	90	93	16	90	93	95	97	100	103	105	90	93
17	91	94	96	98	101	104	106	91	94	17	91	94	96	98	101	104	106	91	94
18	92	95	97	99	102	105	107	92	95	18	92	95	97	99	102	105	107	92	95
19	93	96	98	100	103	106	108	93	96	19	93	96	98	100	103	106	108	93	96
20	94	97	99	101	104	107	109	94	97	20	94	97	99	101	104	107	109	94	97
21	95	98	100	102	105	108	110	95	98	21	95	98	100	102	105	108	110	95	98
22	96	99	101	103	106	109	111	96	99	22	96	99	101	103	106	109	111	96	99
23	97	100	102	104	107	110	112	97	100	23	97	100	102	104	107	110	112	97	100
24	98	101	103	105	108	111	113	98	101	24	98	101	103	105	108	111	113	98	101
25	99	102	104	106	109	112	114	99	102	25	99	102	104	106	109	112	114	99	102
26	100	103	105	107	110	113	115	100	103	26	100	103	105	107	110	113	115	100	103
27	101	104	106	108	111	114	116	101	104	27	101	104	106	108	111	114	116	101	104
28	102	105	107	109	112	115	117	102	105	28	102	105	107	109	112	115	117	102	105
29	103	106	108	110	113	116	118	103	106	29	103	106	108	110	113	116	118	103	106
30	104	107	109	111	114	117	119	104	107	30	104	107	109	111	114	117	119	104	107
31	105	108	110	112	115	118	120	105	108	31	105	108	110	112	115	118	120	105	108

Normal										August 1923									
Day	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Day	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue
1	75	78	80	82	85	88	90	75	78	1	75	78	80	82	85	88	90	75	78
2	76	79	81	83	86	89	91	76	79	2	76	79	81	83	86	89	91	76	79
3	77	80	82	84	87	90	92	77	80	3	77	80	82	84	87	90	92	77	80
4	78	81	83	85	88	91	93	78	81	4	78	81	83	85	88	91	93	78	81
5	79	82	84	86	89	92	94	79	82	5	79	82	84	86	89	92	94	79	82
6	80	83	85	87	90	93	95	80	83	6	80	83	85	87	90	93	95	80	83
7	81	84	86	88	91	94	96	81	84	7	81	84	86	88	91	94	96	81	84
8	82	85	87	89	92	95	97	82	85	8	82	85	87	89	92	95	97	82	85
9	83	86	88	90	93	96	98	83	86	9	83	86	88	90	93	96	98	83	86
10	84	87	89	91	94	97	99	84	87	10	84	87	89	91	94	97	99	84	87
11	85	88	90	92	95	98	100	85	88	11	85	88	90	92	95	98	100	85	88
12	86	89	91	93	96	99	101	86	89	12	86	89	91	93	96	99	101	86	89
13	87	90	92	94	97	100	102	87	90	13	87	90	92	94	97	100	102	87	90
14	88	91	93	95	98	101	103	88	91	14	88	91	93	95	98	101	103	88	91
15	89	92	94	96	99	102	104	89	92	15	89	92	94	96	99	102	104	89	92
16	90	93	95	97	100	103	105	90	93	16	90	93	95	97	100	103	105	90	93
17	91	94	96	98	101	104	106	91	94	17	91	94	96	98	101	104	106	91	94
18	92	95	97	99	102	105	107	92	95	18	92	95	97	99	102	105	107	92	95
19	93	96	98	100	103	106	108	93	96	19	93	96	98	100	103	106	108	93	96
20	94	97	99	101	104	107	109	94	97	20	94	97	99	101	104	107	109	94	97
21	95	98	100	102	105	108	110	95	98	21	95	98	100	102	105	108	110	95	98
22	96	99	101	103	106	109	111	96	99	22	96	99	101	103	106	109	111	96	99
23	97	100	102	104	107	110	112	97	100	23	97	100	102	104	107	110	112	97	100
24	98	101	103	105	108	111	113	98	101	24	98	101	103	105	108	111	113	98	101
25	99	102	104	106	109	112	114	99	102	25	99	102	104	106	109	112	114	99	102
26	100	103	105	107	110	113	115	100	103	26	100	103	105	107	110	113	115	100	103
27	101	104	106	108	111	114	116	101	104	27	101	104	106	108	111	114	116	101	104
28	102	105	107	109	112	115	117	102	105	28	102	105	107	109	112	115	117	102	105
29	103	106	108	110	113	116	118	103	106	29	103	106	108	110	113	116	118	103	106
30	104	107	109	111	114	117	119	104	107	30	104	107	109	111	114	117	119	104	107
31	105	108	110	112	115	118	120	105	108	31	105	108	110	112	115	118	120	105	108

Chart I. Departure (°F.) of the Mean Temperature from the Normal, August, 1928



Shaded portions show excess (+).
Unshaded portions show deficiency (-).
Lines show amount of excess or deficiency.

Chart II. Tracks of Centers of Anticyclones, August, 1928. (Inset) Departure of Monthly Mean Pressure from Normal (Plotted by Wilfred P. Day)

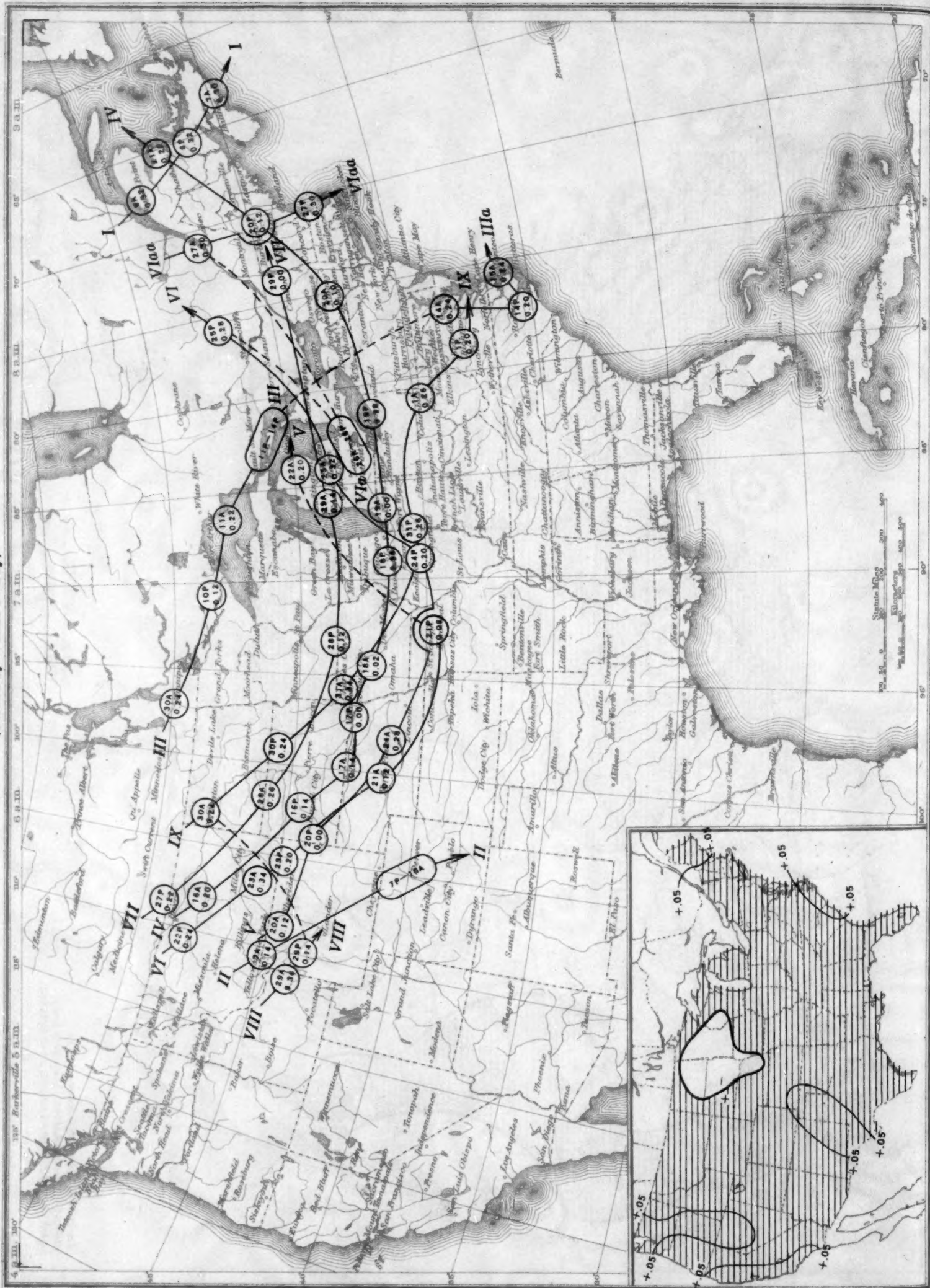
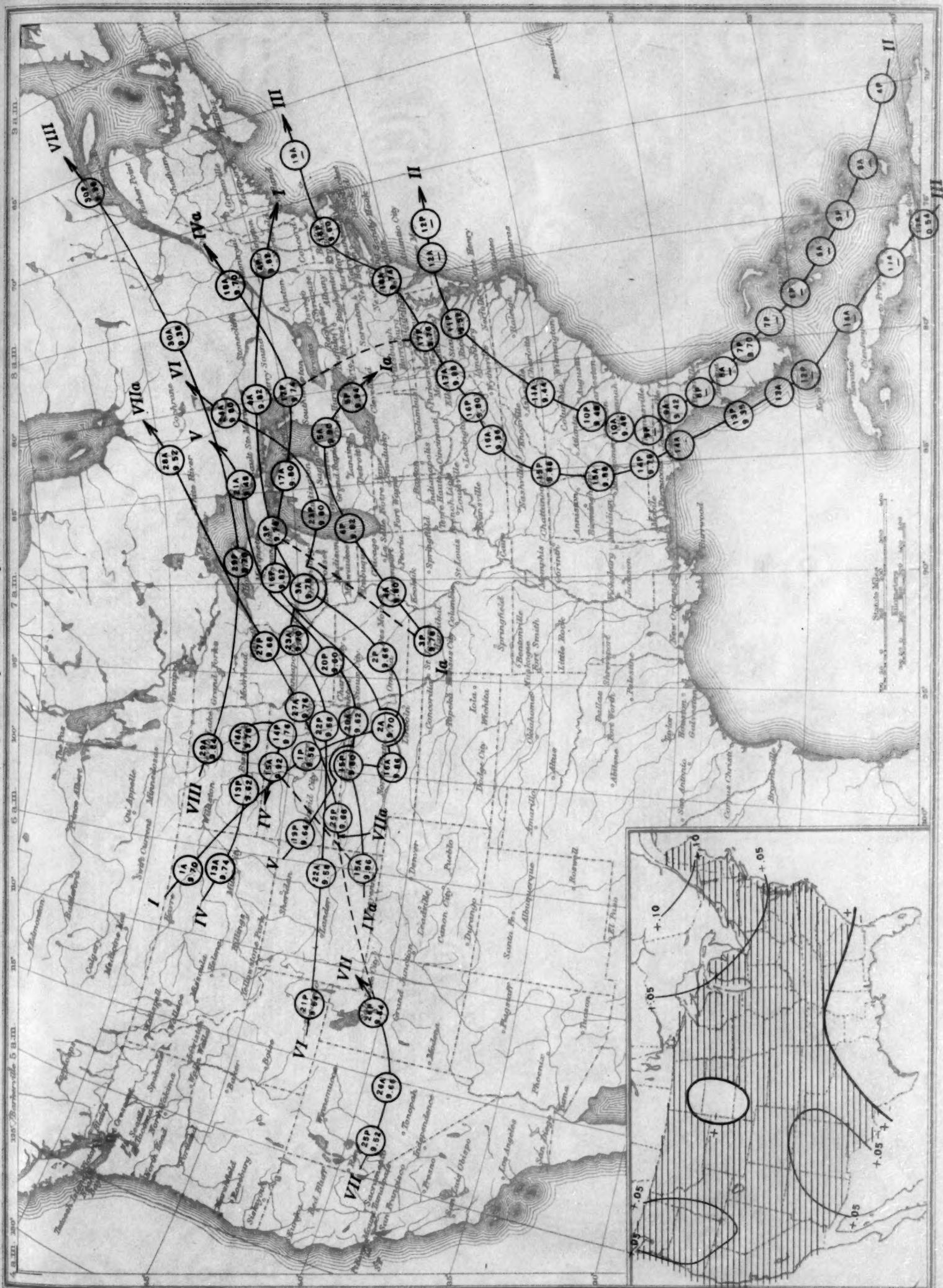


Chart III. Tracks of Centers of Cyclones, August, 1928. (Inset) Change in Mean Pressure from Preceding Month (Plotted by Wilfred P. Day)

Chart III. Tracks of Centers of Cyclones, August, 1928. (Inset) Change in Mean Pressure from Preceding Month (Plotted by Wilfred P. Day)



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Chart IV. Percentage of Clear Sky between Sunrise and Sunset, August, 1928

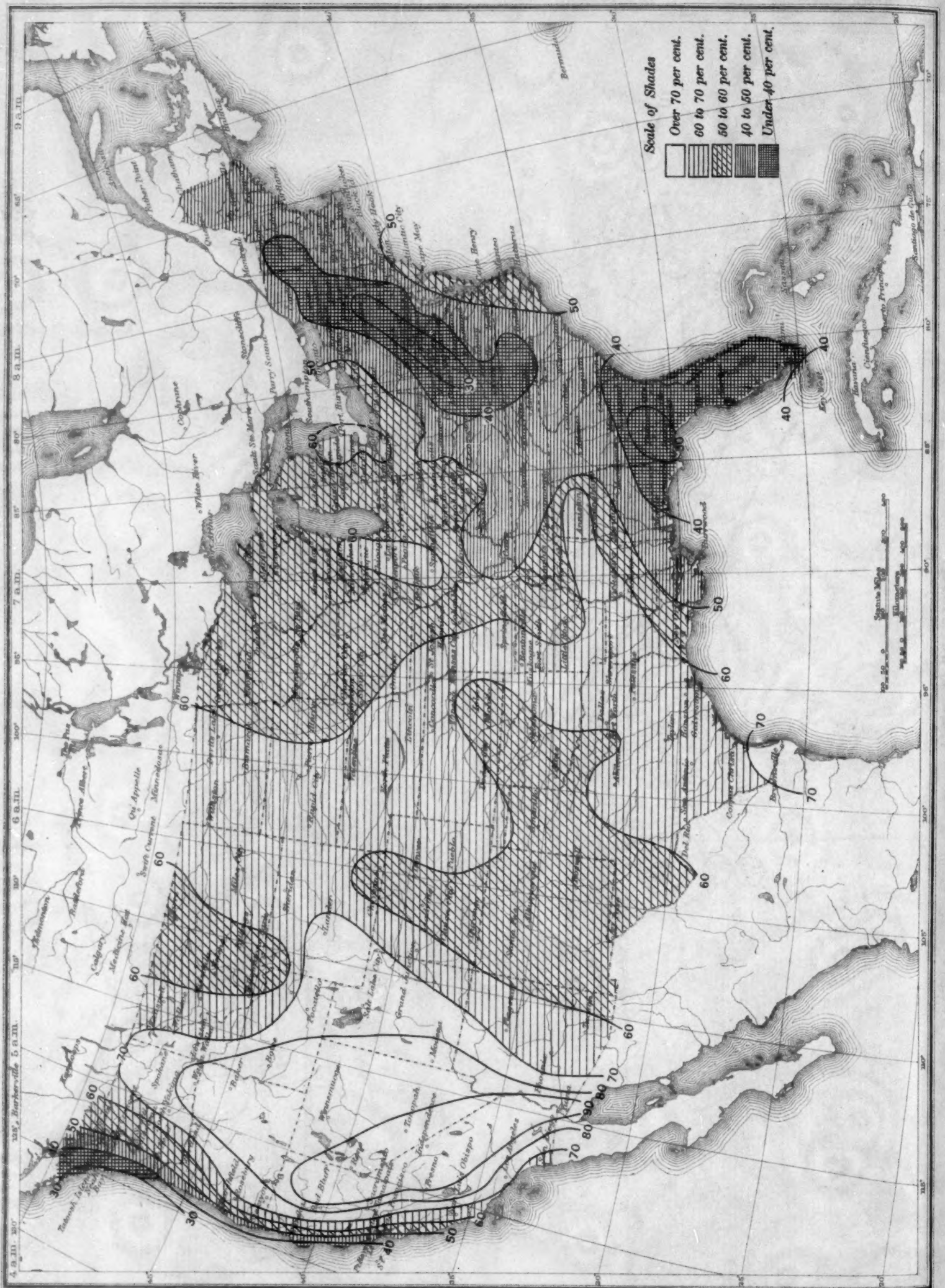


Chart V. Total Precipitation, Inches, August, 1928. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, August, 1928. (Inset) Departure of Precipitation from Normal

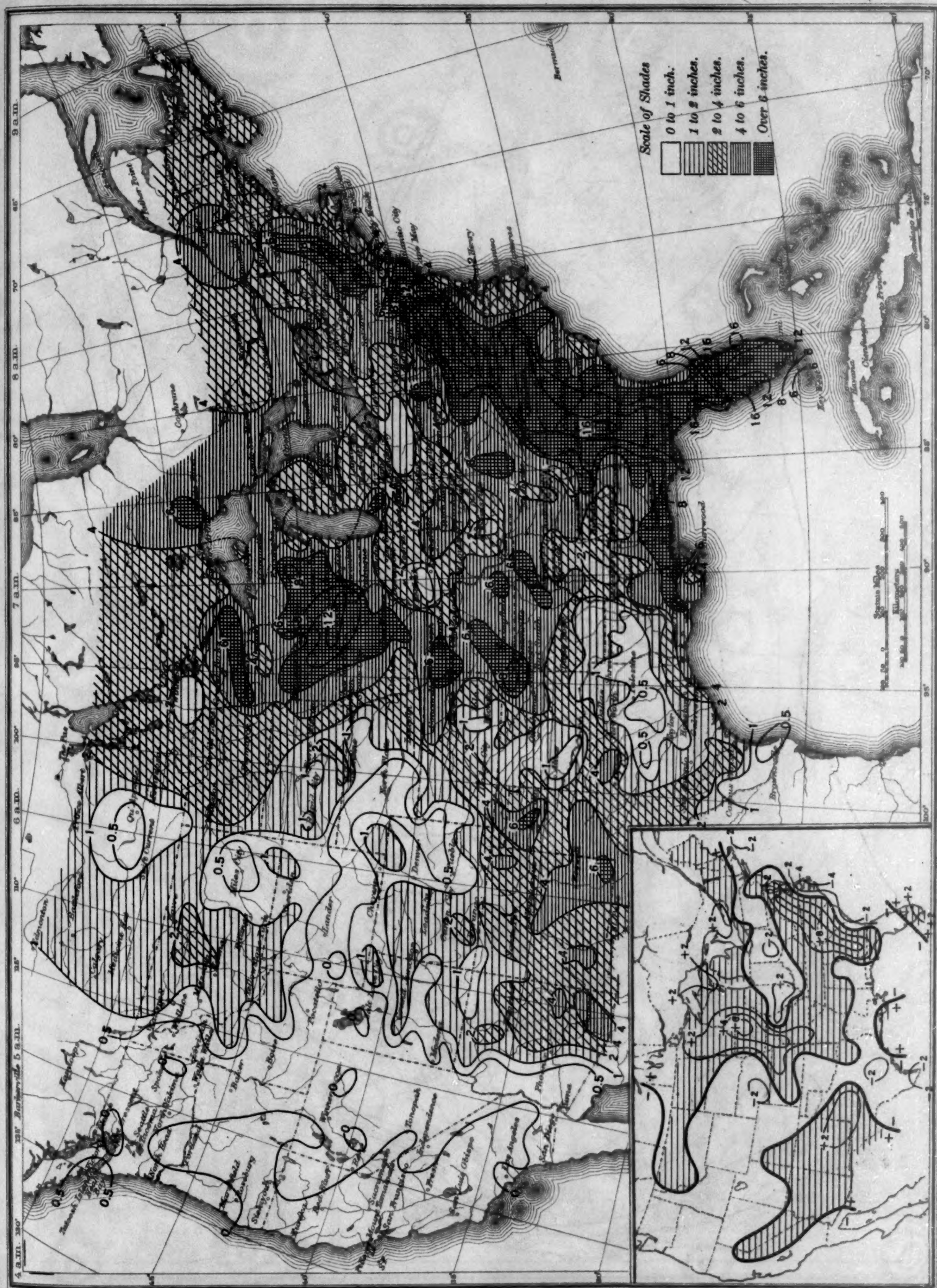


Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, August, 1928

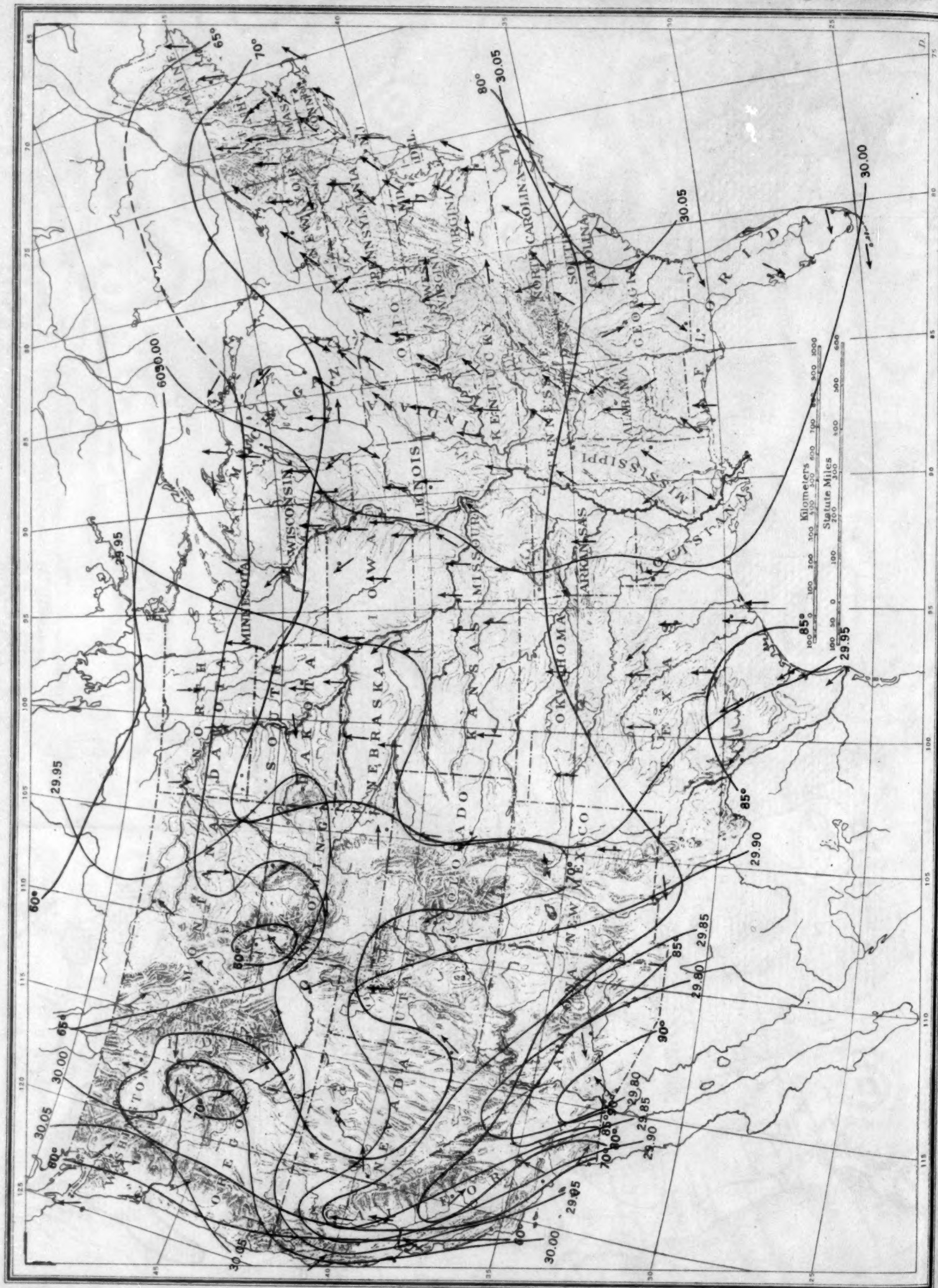


Chart VIII. Weather Map of North Atlantic Ocean, August 7, 1928
(Plotted by F. A. Young)

Chart VIII. Weather Map of North Atlantic Ocean, August 7, 1928
(Plotted by F. A. Young)

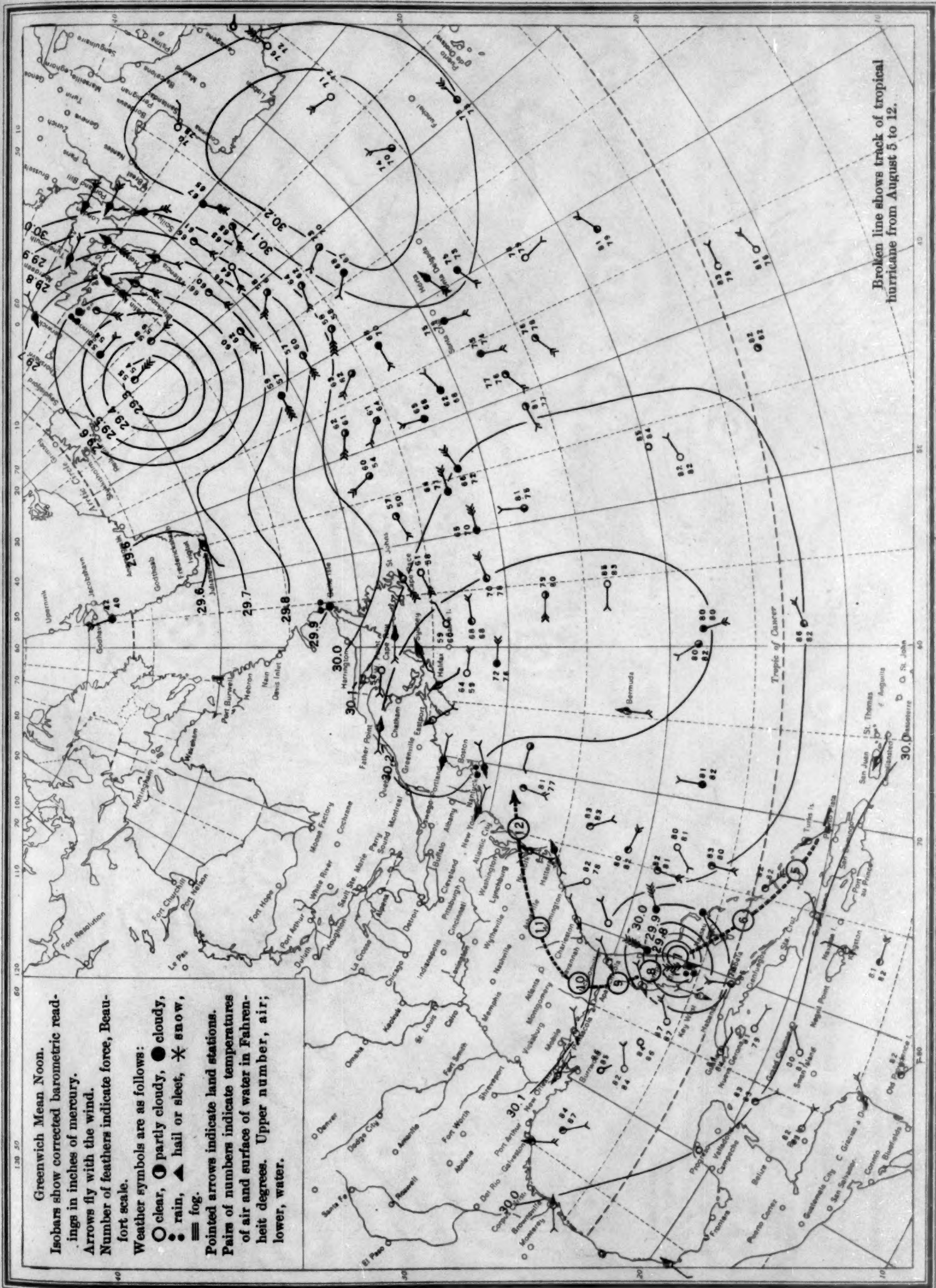
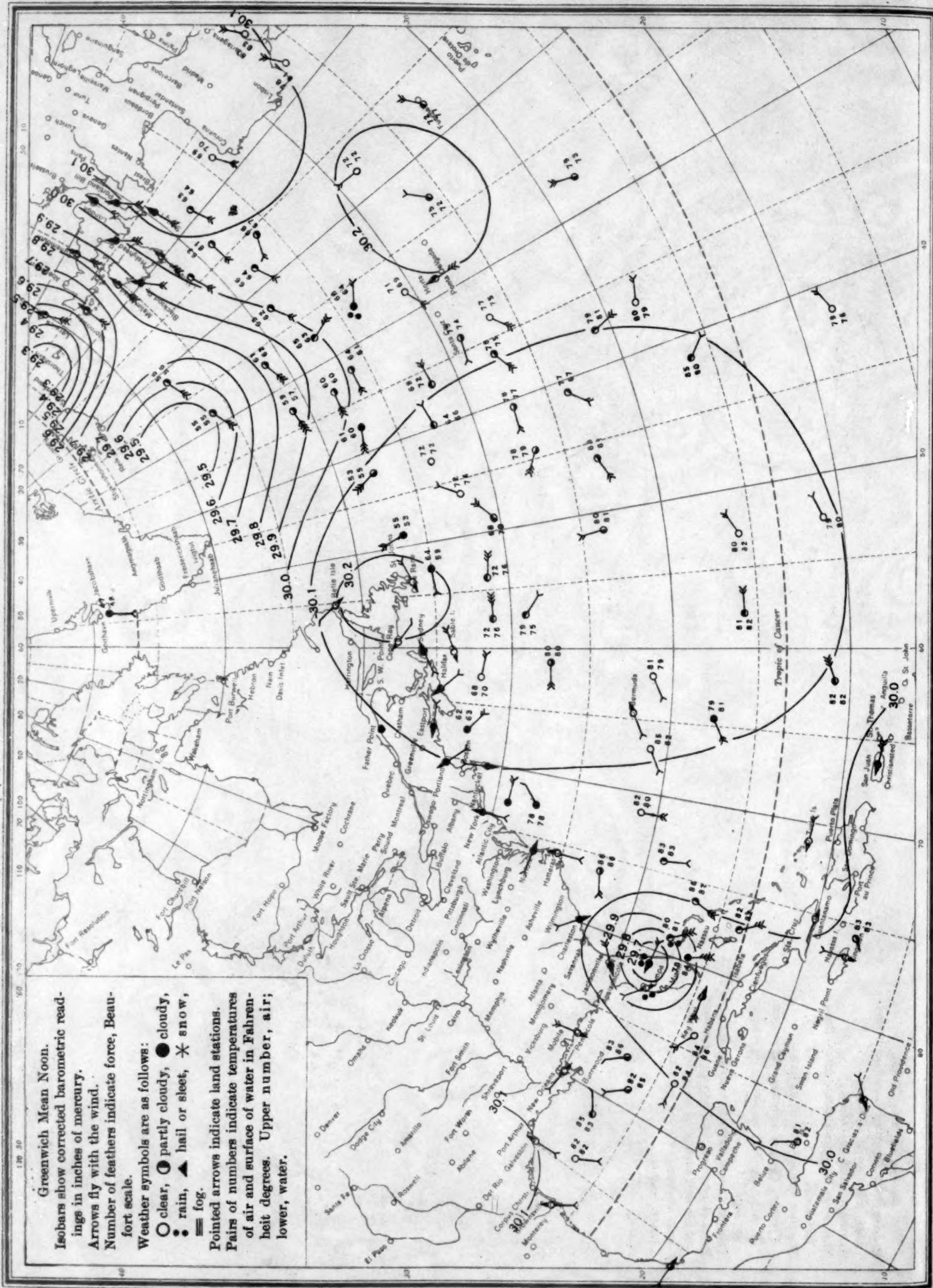


Chart IX. Weather Map of North Atlantic Ocean, August 8, 1928

(Plotted by F. A. Young)



Greenwich Mean Noon.

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

Number of feathers indicate force, Beaufort scale.

Weather symbols are as follows:

- clear, ◐ partly cloudy, ● cloudy,
- rain, ▲ hail or sleet, * snow, — fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.

Chart X. Weather Map of North Atlantic Ocean, August 9, 1928

(Plotted by F. A. Young)

Chart X. Weather Map of North Atlantic Ocean, August 9, 1928
(Plotted by F. A. Young)

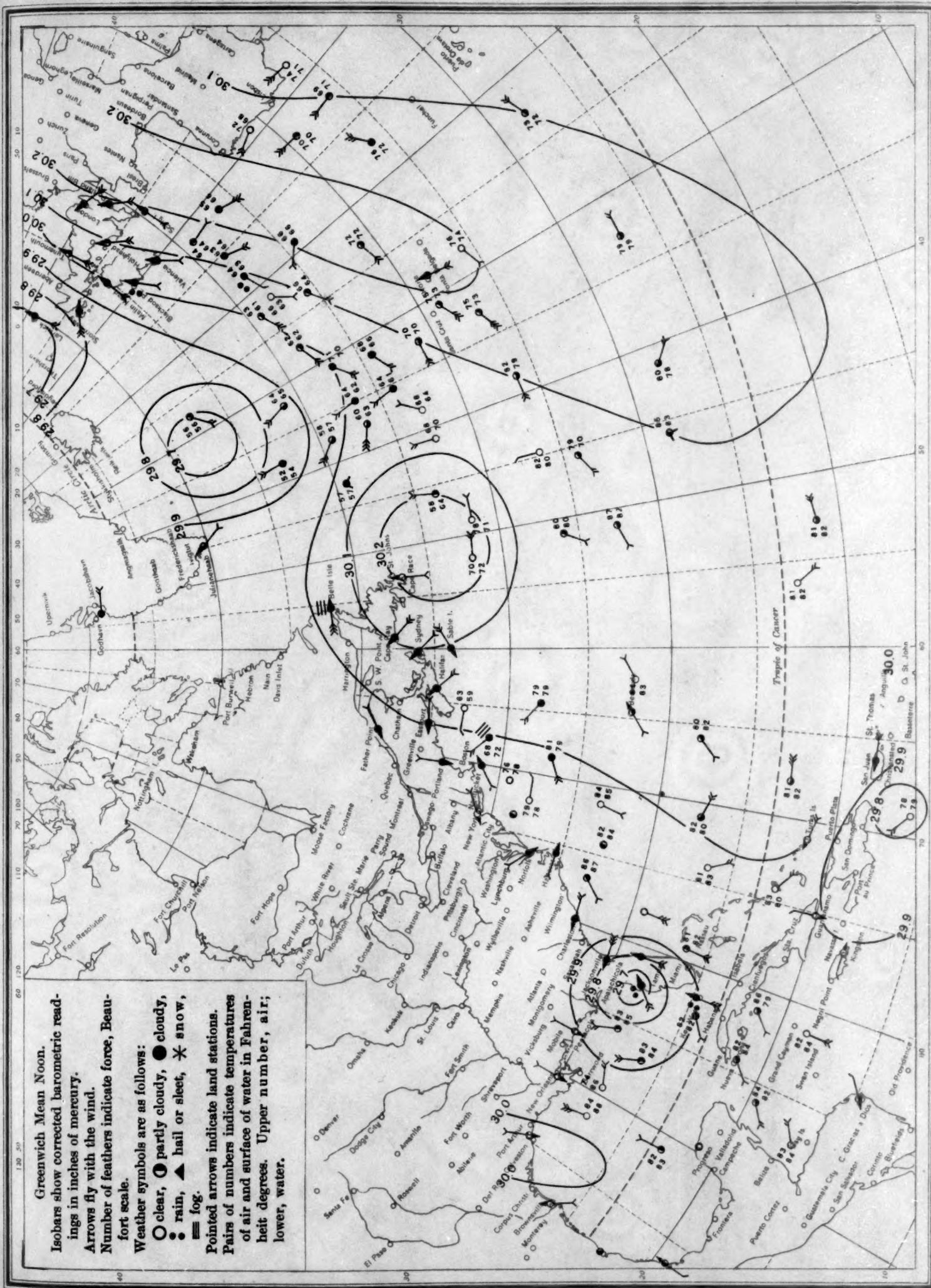


Chart XI. Weather Map of North Atlantic Ocean, August 10, 1928
(Plotted by F. A. Young)

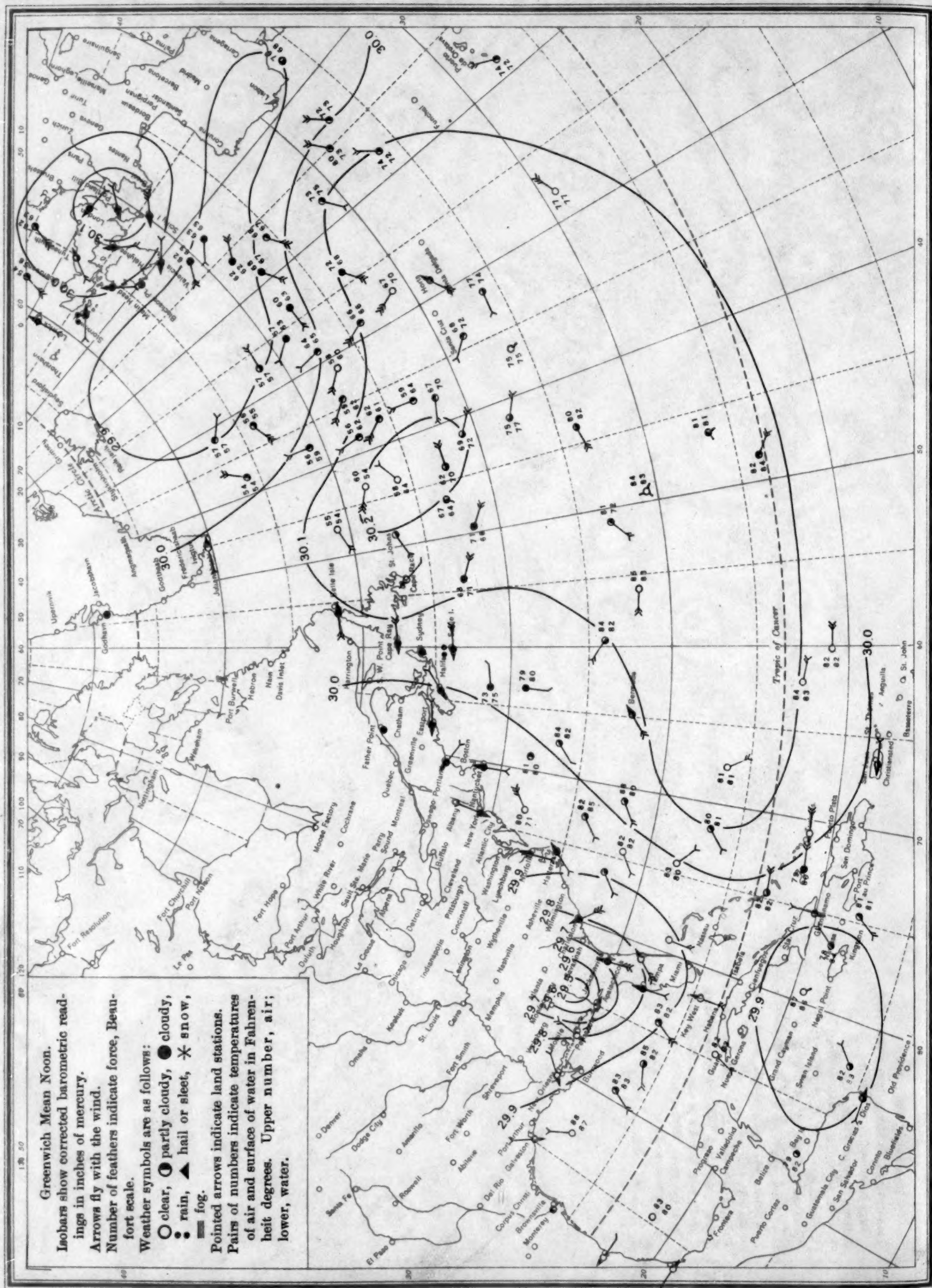


Chart XII. Weather Map of North Atlantic Ocean, August 11, 1928
(Plotted by F. A. Young)

Chart XII. Weather Map of North Atlantic Ocean, August 11, 1928
(Plotted by F. A. Young)

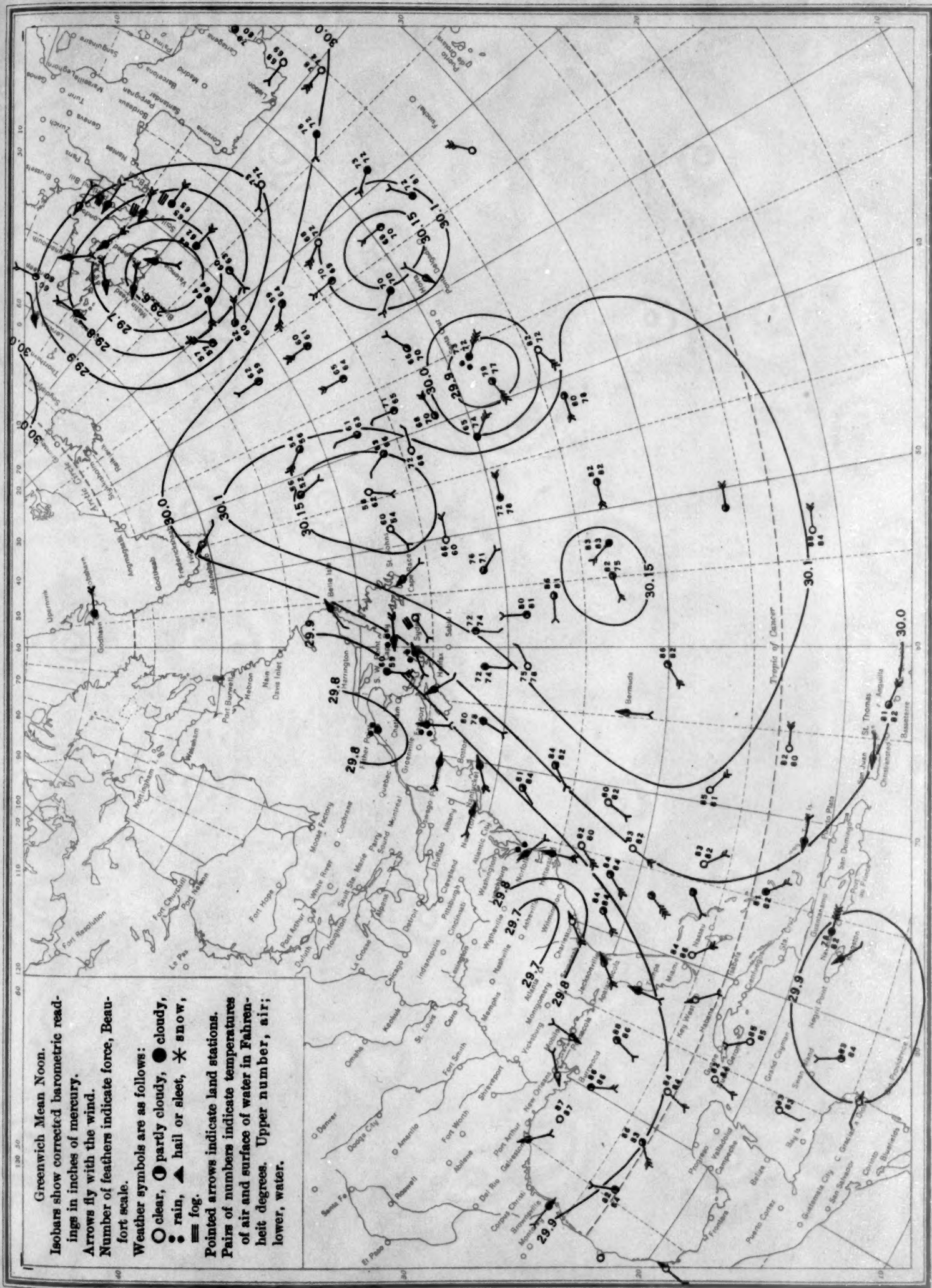


Chart XIII. Weather Map of North Atlantic Ocean, August 12, 1928
(Plotted by F. A. Young)

